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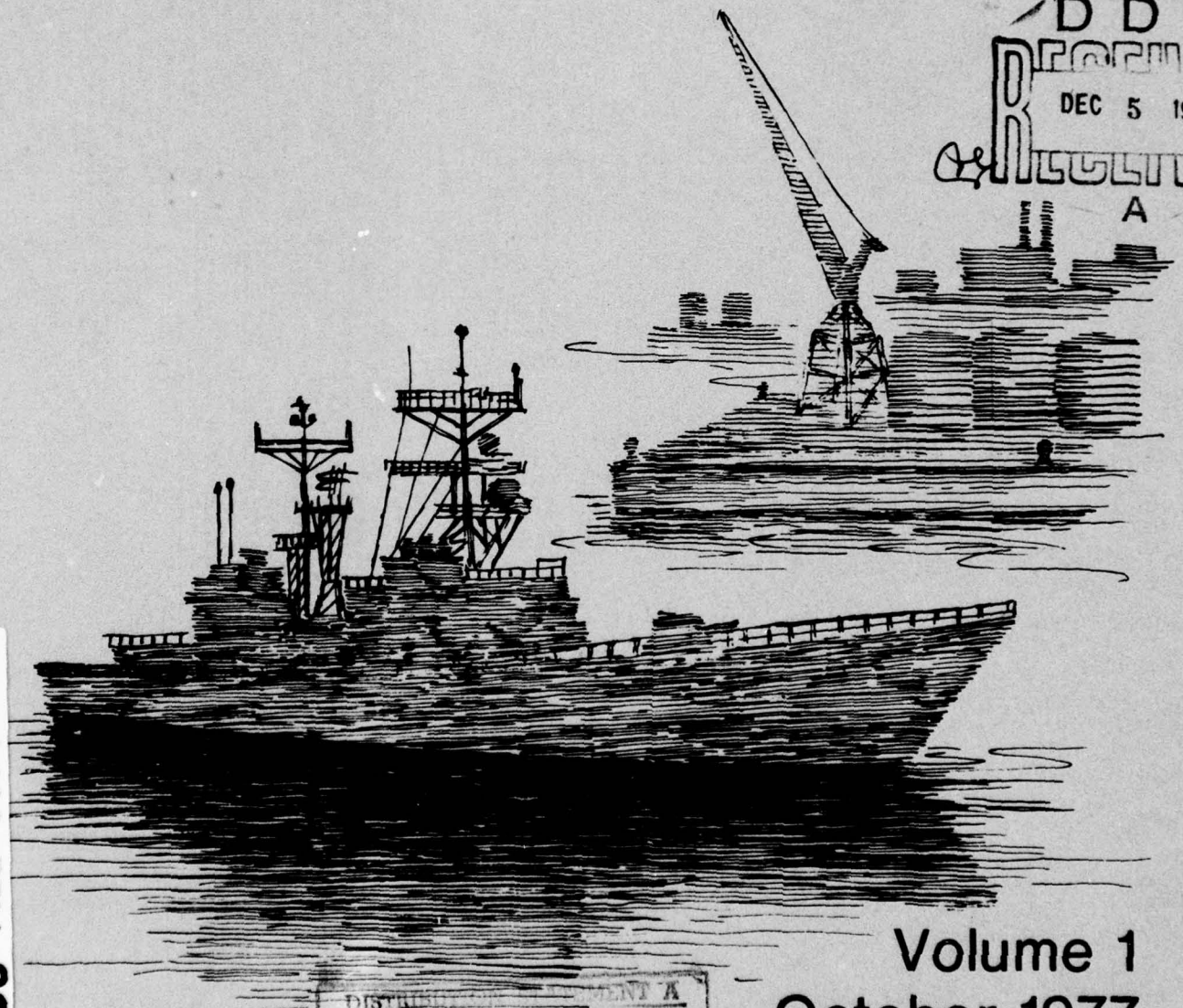

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PREPARED UNDER THE DIRECTION OF THE DIRECTOR, NAVY ENERGY AND NATURAL RESOURCES RESEARCH AND DEVELOPMENT OFFICE

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This document presents a program plan developed to establish a course of action whereby the Director, Navy Energy R&D Office, may effectively carry out the responsibilities of his assigned charter, and to provide the Navy with a structured approach to energy R&D that responds to Navy energy requirements and at the same time complements and becomes an integral part of the national and Department of Defense energy R&D programs. Also discussed in this document is the methodology used in developing the plan, including the selection of goals, strategies and objectives for the Navy Energy R&D program.

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FOREWORD

The Navy Energy Research and Development (R&D) Program Plan, developed by the Navy Energy and Natural Resources R&D Office, is being forwarded for policy-level review and approval. A draft plan was reviewed at the working and staff levels by appropriate system commands, laboratories, and offices. Following this review, approved changes were incorporated.

Volume 1 of the plan presents the overall philosophy of the energy program and its development together with a summary of the individual work units. Volume 2 contains the details of the ongoing program for use primarily by those who monitor the program. The Energy R&D Program Plan is a working document. The plan is in a loose-leaf binder so that it can be updated easily. The Navy Energy and Natural Resources R&D Office, MAT-08T3, will send updated pages to those on the distribution list as revisions are made. Recommended changes should be forwarded to Chief of Naval Material (MAT-08T3), Navy Material Command, Washington, D.C. 20360.

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ABBREVIATIONS

AEUTB	Advanced Energy Utilization Test Bed
ASD	Assistant Secretary of Defense
ASN	Assistant Secretary of the Navy
BOE	Barrels of Oil Equivalent
BOM	Bureau of Mines
BUMED	Bureau of Medicine
CEL	Civil Engineering Laboratory
CNM	Chief of Naval Material
CNO	Chief of Naval Operations
COED	Char-Oil Energy Development
CONUS	Continental United States
DCNO	Deputy Chief of Naval Operations
DC/S RD&S	Deputy Chief of Staff for Research, Development and Studies
DDR&E	Director, Defense Research and Engineering
DEIS	Defense Energy Information System
DETG	Defense Energy Task Group
DFSC	Defense Fuel Supply Center
DLA	Defense Logistics Agency
DOD	Department of Defense
DOE	Department of Energy
DOI	Department of Interior
DSFSG	Defense Synthetic Fuels Steering Group
DTNSRDC	David Taylor Naval Ship Research and Development Center
ECIP	Energy Conservation Investment Program
EMCS	Energy Monitoring and Control System
EPA	Environmental Protection Agency
EPCA	Energy Policy and Conservation Act
EPRI	Electric Power Research Institute
ERDA	Energy Research and Development Administration
FEA	Federal Energy Administration
FPC	Federal Power Commission
FR/IED	Foundation Research and Independent Exploration Development
FYDP	Five-Year Development Plan
HQMC	Headquarters, Marine Corps

HVAC	Heating, Ventilating, and Air Conditioning
ISA	International Security Affairs
JCS	Joint Chiefs of Staff
JSCERDCG	Joint Services Civil Engineering R&D Coordination Group
LNG	Liquid Natural Gas
MARAD	Maritime Administration
MCDEC	Marine Corps Development and Education Command
MOU	Memorandum of Understanding
MRA&L	Manpower, Reserve Affairs, and Logistics
NAD	Naval Ammunition Depot
NADC	Naval Air Development Center
NAPTC	Naval Air Propulsion Test Center
NASA	National Aeronautics and Space Administration
NAVAIR	Naval Air Systems Command
NAVFAC	Naval Facilities Engineering Command
NAVMAT	Naval Material Command
NAVSEA	Naval Sea Systems Command
NAVSEC	Naval Ship Engineering Center
NBS	National Bureau of Standards
NRL	Naval Research Laboratory
NSGA	Naval Security Group Activity
NSRDC	Naval Ship Research and Development Center
NWC	Naval Weapons Center
OCS	Outer Continental Shelf
O&M	Operations and Maintenance
OMB	Office of Management and Budget
ONR	Office of Naval Research
OSD	Office of the Secretary of Defense
PA	Public Affairs
P&E	Planning and Evaluation
POL	Petroleum-Oil-Lubricants
POM	Program Objectives Memorandum
PWC	Public Works Center
PWRMR	Prepositioned War Reserve Materiel Requirements
R&D	Research and Development
RD&D	Research, Development, and Demonstration
RDF	Refuse-Derived Fuel
RDT&E	Research, Development, Test, and Evaluation
RE&S	Research, Engineering and Systems

RFP	Request for Proposals
STEM	Shipboard Total Energy Model
SYSCOM	Systems Command
USGS	U.S. Geological Survey

EXECUTIVE SUMMARY

This Navy Energy Research and Development (R&D) Program Plan, defining a course of action for the Navy, is the principal management tool of the Director, Navy Energy and Natural Resources R&D Office (MAT-08T3). The plan provides a structured approach to a well-integrated energy R&D program (exclusive of nuclear energy) and implements the direction and guidance of the Navy Energy Plan, developed by the Navy Energy Office (OP-413).

The Navy Energy R&D Program Plan has been developed with the objective of finding solutions to the energy and energy-related problems confronting the Navy. Among the most critical problems are the need to conserve existing energy resources and to find alternative resources. In solving these two, a third problem—escalating energy costs—is also addressed. Analyses of these problems and the definition of a plan to cope with them have been undertaken in conjunction with an understanding of the energy programs conducted within the Department of Defense (DOD) and other, nonmilitary, government agencies.

Based on these analyses, energy R&D goals, strategies, and objectives were developed and refined to guide the projects and tasks being performed by the Naval Systems Commands (SYSCOMs), laboratories, and related R&D facilities. The Navy energy R&D budget structure was revised in accordance with these strategies for more effective staff review and improved coordination.

BACKGROUND

The nation faces continuing, serious energy problems involving limited choices and continued dependence on diminishing oil and gas resources, with increasing reliance on imported fuels. U.S. demand for petroleum products, which decreased somewhat in 1974 and 1975, has been increasing and now exceeds the 1973 level; 1976 energy requirements totaled 12.6 billion barrels of oil equivalent (BOE). DOD, the largest single energy consumer in the United States, required about 3 percent of this amount directly and another 2 to 3 percent indirectly through defense-related industries (based on FY 1976 data). In wartime, DOD's portion of the national energy consumption would increase by at least a factor of three. About 68 percent of the energy used by DOD is in the form of petroleum products. The Navy's portion of the energy required by DOD is 34 percent, of which 73 percent is in the form of petroleum products. Since the types of ships and aircraft now in operation will continue to be the mainstay of the Navy until the turn of the century (unless they are modified extensively), liquid hydrocarbons will continue to be the primary fuel well into the twenty-first century.

While the U.S. demand for energy has increased, domestic petroleum production, which peaked at about 11.6 million barrels per day in 1970, has been decreasing at a rate of about 2.3 percent per year, although there will be a short-term decrease due to Alaskan oil. In 1976, domestic petroleum production averaged 9.8 million barrels per day. Petroleum imports in 1976 averaged 7.4 million barrels per day (about 43 percent of demand), up from the 1973 average of 6.3 million barrels per day. In March 1976, petroleum imports averaged 8.2 million barrels per day, exceeding domestic production for the first time in the history of the United States.

With imports at 43 percent of demand, the United States faces the dilemma of vulnerability through importing oil and the rapid depletion of its own supplies. The problem was emphasized by the 1973-1974 oil embargo, which highlighted how vulnerable the United States could be to energy supply disruptions. Yet, the total fossil energy demand forecast to 2050 indicates increasing dependence on imported fuels at increasing costs. Increased exploration and development costs and lower discovery rates add to the problem. Furthermore, no political action or technological breakthrough that would completely relieve the United States of its dependence on imported oil is anticipated. Therefore, the United States must develop new domestic energy sources in an effort to reduce its dependence on petroleum-derived fuels to an acceptable level.

To improve the U.S. energy situation, the President, in April 1977, announced seven specific energy goals for 1985:

- Reduce the annual growth rate in U.S. energy demand to less than 2 percent.
- Reduce gasoline consumption by 10 percent below its current level.
- Cut in half the portion of U.S. oil that is imported from a potential level of 16 million barrels to 6 million barrels a day.
- Establish a strategic petroleum reserve of 1 billion barrels, more than a 6-month supply.
- Increase coal production by about two-thirds, to more than 1 billion tons a year.
- Insulate 90 percent of American homes and all new buildings.
- Use solar energy in more than 2.5 million houses.

The objectives of the national energy plan are:

- In the short term, to reduce dependence on foreign oil and limit supply disruptions.
- In the medium term, to weather the eventual decline in the availability of world oil supplies caused by capacity limitations.
- In the long term, to develop renewable and essentially inexhaustible sources of energy for sustained economic growth.

The major strategies for reaching these objectives are:

- Implementation of an effective conservation program for all sectors of energy use to reduce the rate of demand growth to less than 2 percent, thereby helping to achieve both the short- and medium-term goals.

- Conversion of industry and utilities using oil and natural gas to coal and other more abundant fuels to reduce imports and make natural gas more widely available for household use, thereby helping to achieve both the short- and medium-term goals.
- A vigorous research and development program to provide renewable and essentially inexhaustible resources to meet U.S. energy needs in the next century, thereby helping to achieve the long-term goal.

Given its dependence on petroleum fuels, the Navy cannot afford to take a passive role in solving the nation's energy problems. The Navy must continue to pursue an aggressive energy R&D program while establishing energy policies and guidelines that will minimize the impact of any future oil embargoes or energy shortfalls.

ENERGY R&D GOALS, STRATEGIES, AND OBJECTIVES[1]

This document is integral with and conforms to overall planning and policy guidance of the Navy Energy Plan as well as the recently announced national energy program goals. But long before the national program was identified, DOD took steps to define energy R&D goals and policy guidance with the establishment of the Defense Energy Task Group (DETG) in September 1973. Because of the Navy's earlier anticipation of the fuel availability problem, it assumed a leading role in the DETG effort.

On 3 August 1972, a year before the embargo, the Assistant Secretary of the Navy for Research and Development—now Research, Engineering and Systems [ASN(RE&S)]—initiated an assessment of the impact and definition of the appropriate Navy response to an anticipated crisis in the availability of petroleum fuels. The resulting study group concluded that an energy crisis would eventually occur and recommended actions to offset such a crisis. The Navy Energy and Natural Resources R&D Office, MAT-08T3, was informally established in July 1973 and formally chartered in February 1974 under the Chief of Naval Material (CNM) to develop comprehensive R&D plans related to Navy energy problems.

In developing an energy R&D program, the first consideration was the immediate requirements of a petroleum shortage caused by the 1973-1974 oil embargo; therefore, short-term fuel reduction measures were implemented. However, potential long-range solutions were also identified, and analytical studies of these solutions were initiated. These analyses led to formulation of a set of energy goals, with the primary emphasis on reducing Navy dependence on foreign energy supplies and minimizing the adverse impact of increasing fuel prices on Navy operations. Attainment of these goals is related to increasing the efficiency and reliability of energy-using systems without compromising flexibility, readiness, or performance, and to ensuring that the Navy can make a smooth

[1]Navy energy R&D goals, strategies, and objectives are defined as follows: a technological goal is the broadest possible statement defining R&D aims that can be effected with respect to the prescribed mission of the Navy; a strategy is one of several approaches that has been selected as a means of meeting the R&D goals of the Navy; and an objective is a specific end point or position to be attained.

transition from rapidly depleting traditional energy sources to synthetic fuels and renewable energy forms.

The Navy has selected three approaches or strategies to achieve its goals: energy conservation, synthetic fuels, and energy self-sufficiency. Through an energy conservation program, the Navy is eliminating wasteful use of fuel and is developing more efficient propulsion and power generation systems. The Navy's approach in synthetic fuels is to support national programs for commercialization and to initiate both laboratory and operational test projects that will ensure compatibility between these fuels and Navy equipment. To increase its energy self-sufficiency, the Navy is developing local renewable energy sources at both remote and domestic bases (e.g., solid waste, wind, solar, geothermal) and, where possible, replacing liquid hydrocarbon fuels at domestic bases with more abundant fuels such as coal.

Using these three approaches to solving the energy problem, the Navy has established several objectives:

- ***Energy Conservation.***
  - Develop, test, and evaluate shore-based systems that will use energy more efficiently.
  - Develop, test, and evaluate present and future propulsion and auxiliary systems and methods for reducing hull drag to achieve greater efficiency and cost-effectiveness in Navy vessels.
  - Promote energy conservation through the continued development of equipment operating procedures and technical expertise and the distribution of engineering publications.
  - Develop, test, and evaluate more energy-efficient aircraft systems (for both current inventory aircraft and advanced designs) and modifications in operational concepts, tactics, and equipments that will reduce fuel usage.
- ***Synthetic Fuels.***
  - Determine the characteristics of military fuels produced from synthetic crude.
  - Test, evaluate, and apply appropriate engineering expertise to ensure that synthetic fuels and Navy hardware are compatible.
  - Certify synthetic fuels for Service use and issue specifications and fleet implementation guidelines.
  - Certify nonspecification petroleum fuels for Navy use.
- ***Energy Self-sufficiency.***
  - Test and evaluate energy systems that would be more self-sufficient, reduce the use of liquid hydrocarbons, or both.
  - Utilize renewable sources of energy such as combustible wastes, geothermal, wind, solar, and other sources where available.
  - Select and demonstrate the most cost-effective technology for energy self-sufficiency.
  - Promote energy self-sufficiency through continued development of technical expertise in energy systems and distribution of engineering publications.

The only significant near-term solution to the decreasing availability of energy sources and increasing costs is conservation. Therefore, energy conservation is a major

part of the Navy's R&D program. Primarily, the Navy's conservation effort involves developing and implementing new technologies and operational practices that will reduce energy consumption by improving the design of various systems and using more energy-efficient operating techniques. Consistent with the DETG policy recommendations, the Navy Energy and Natural Resources R&D Office is concentrating on conserving energy on ships and at shore installations. The Air Force will act as the lead Service in military aircraft energy conservation, while the Navy will concentrate on defining Navy requirements and conducting programs that address energy usage aspects peculiar to Navy aircraft operations.

Oil shale, coal, and tar sands—used to make synthetic liquid hydrocarbon fuels—are sufficiently plentiful in the United States to last well into the next century. Extensive R&D programs are being directed toward the use of these resources. Through its synthetic fuel R&D efforts, the Navy will be well informed and will be able to ensure that the fuels resulting from various government- and industry-sponsored synthetic fuels programs will be suitable for Navy needs. The Navy has been assigned the lead Service responsibility within DOD for synthetic fuels efforts. The Energy Research and Development Administration[1] (ERDA) is providing the primary impetus in the development of a synthetic fuels industry, and the Navy and ERDA have joint programs to acquire, refine, test, and evaluate synthetic fuels. As the fuels become available in sufficient quantities, the Navy will ensure compatibility between the synthetic fuels and Navy equipment through testing programs. While it will certify all synthetic fuels, whether derived from coal, tar sands, or oil shale, the Navy is, at this time, concentrating primarily on certifying fuels derived from oil shale. The Navy will also conduct studies to determine the effect of using nonspecification conventional fuels when specification fuels are unattainable or in short supply. The Navy is not stressing research, development, test, and evaluation (RDT&E) of such "exotic" fuels as hydrogen, methane, and alcohol. However, if the economic and operational potential of these fuels becomes acceptable, the Navy will review its priorities. Therefore, the basic design of Navy propulsion systems will probably remain essentially the same throughout the rest of this century.

Development and application of technology to increase energy self-sufficiency within the Navy will decrease its dependence on petroleum supplies—especially at remote locations, which are in more danger of supply line interruption and which involve higher transportation costs. In addition, such an R&D program allows the Navy to be well informed on national efforts to develop energy technologies, e.g., solar conversion systems, that soon may be applied in both civilian and military systems. In its self-sufficiency activities, the Navy is applying systems and developing resources in a manner that uses conventional and advanced systems in the best possible mix that is economically, environmentally, and strategically sound. The Navy is also coordinating with the Army and Air Force programs and is continuously monitoring R&D projects on energy conversion in the civilian sector, particularly ERDA-sponsored projects.

The following diagram shows how the Navy's energy R&D program corresponds to and supports the national program.

[1]Effective 1 October 1977, ERDA's functions were assumed by the new Department of Energy (DOE). To maintain the identity of those programs originated and, until 1 October 1977, implemented by ERDA no attempt has been made in this document to classify them as DOE programs.

THE NAVY ENERGY R&D PROGRAM SUPPORTS NATIONAL ENERGY GOALS

	NATIONAL GOALS / NAVY OBJECTIVES	REDUCE ANNUAL ENERGY DEMAND GROWTH RATE TO LESS THAN 2 PERCENT	REDUCE GASOLINE CONSUMPTION BY 10 PERCENT	CUT OIL IMPORTS TO ONE-HALF OF 1985 PROJECTION	ESTABLISH 1 BILLION BARREL STRATEGIC PETROLEUM RESERVE	INCREASE COAL PRODUCTION TO 1 BILLION TONS PER YEAR	INSULATE 90 PERCENT OF U.S. HOMES AND ALL NEW BUILDINGS	USE SOLAR ENERGY IN MORE THAN 2.5 MILLION HOUSES
CONSERVATION	REDUCE SHIP DRAG	■		■				
	DEVELOP MORE EFFICIENT SHIP PROPULSION AND AUXILIARY SYSTEMS	■		■				
	DEVELOP MORE EFFICIENT SHORED-BASED SYSTEMS	■		■			■	
	DEVELOP BETTER TRAINING AND OPERATING PROCEDURES	■	■	■				
	DEVELOP MORE EFFICIENT AIRCRAFT SYSTEMS	■		■				
	REDUCE FUEL CONSUMPTION BY MODIFYING OPERATIONAL CONCEPTS/FUNCTIONS	■		■				
SYNTHETIC FUELS	CHARACTERIZE MILITARY FUELS FROM SYNCRUDES			■		▨		
	ENSURE COMPATIBILITY BETWEEN SYNFUELS AND SYSTEMS			■		▨		
	QUALIFY NON-SPECIFICATION FUELS FOR NAVY USE		■					
SELF-SUFFICIENCY	DEVELOP SYSTEMS LESS DEPENDENT ON OIL OR NATURAL GAS			■		■		■
	USE RENEWABLE ENERGY SOURCES: WIND, GEOTHERMAL, SOLAR, TRASH, OTHER		■	■				■

■ DIRECT SUPPORT ▨ RELATED SUPPORT □ DOES NOT APPLY

NAVY ENERGY R&D PROGRAM PLAN

The Navy energy R&D program encompasses 118 ongoing and planned energy projects. Of these, there are 67 conservation, 10 synthetic fuels, and 41 self-sufficiency projects. In addition, there are, within the Navy, seven energy-related support projects—four Naval Research Laboratory (NRL) and three Naval Air Systems Command (NAVAIR)—and over 25 energy-related projects being performed under interagency agreements by the Navy, but funded by other government agencies.

Energy Conservation

The David Taylor Naval Ship R&D Center (DTNSRDC) is the lead laboratory for the Navy's R&D on shipboard energy conservation, and serves as the tasking authority to other organizations participating in the shipboard program. Research is also being performed by the Naval Ship Engineering Center (NAVSEC), Office of Naval Research (ONR), and NRL. Existing or planned tasks directed toward achieving a 20 percent saving in shipboard energy consumption include:

- Ship energy system analysis of the existing and future fleet.
- Improved hull cleaning and coating techniques.
- Improved machinery and operator techniques for the existing fleet.
- Advanced ship components for the future fleet.

The Naval Facilities Engineering Command (NAVFAC) and the Civil Engineering Laboratory (CEL) are performing the R&D efforts to conserve energy at the Navy's shore facilities. The Energy Program Office, located at CEL, coordinates this RDT&E program. This office is developing an energy technology base tailored to Navy needs; it assimilates technological advances made by the national energy program, evaluates hardware at CEL, and applies appropriate technologies to NAVFAC and other field activities. The goal in shore-facility energy conservation is a 20 percent reduction in energy consumption· this reduction will be made in the following areas:

- Improved/advanced power and utility systems.
- Improved construction materials, concepts, and designs.
- Improved/advanced heating, ventilating, and air conditioning (HVAC) systems.
- Improved lighting systems.
- Energy-loss detection and measurement.
- Applications analyses, data compilation/reduction, and related supporting studies.
- Improved energy monitoring and control systems.

The Naval Air Development Center (NADC) will be conducting the aircraft energy conservation programs. Planned activities will be directed toward analysis of fuel usage by class/type of Navy and Marine Corps aircraft and potential fuel savings solutions through modifications and design changes; new concepts in operational procedures or mission tactics; and new equipments (payloads) to perform mission functions at optimal flight conditions. These tasks will include:

- Current inventory aircraft systems.
- Advanced design concepts.

Synthetic Fuels

A long-range plan for acquisition of test quantities of domestic synthetic fuels is being developed by the Navy in coordination with the Air Force, Army, the National Aeronautics and Space Administration (NASA), and ERDA. These fuels will be tested by the agencies to ensure that adequate procurement specifications are developed by the time synthetic fuels from similar sources are commercially available. Tests will also be conducted to determine the impact on Navy operations and equipment of using nonspecification conventional fuels. The tests to be performed include:

- Aircraft, shipboard, and land-based fuel characterization analyses.
- Fuels and fuel systems compatibility testing.
- Small- and large-scale aircraft engine testing.
- Small- and large-scale shipboard power plant testing.
- Small- and large-scale shore-based power plant testing.
- Full-scale operational sea and flight trials.
- Full-scale shore facility operational trials.

Energy Self-sufficiency

Achieving the maximum measure of energy self-sufficiency for shore installations is the desired goal of this program. This will be accomplished by utilizing natural energy sources contiguous to the using facility. CEL, the principal activity performing R&D in energy self-sufficiency, is supported by the Naval Weapons Center (NWC); together they are responsible for development of:

- Geothermal energy.
- Solar energy.
- Wind generator systems.
- Waste-recovery projects for producing energy.
- Coal utilization technology.
- Application and data analysis studies and demonstration.
- Development of a Navy energy self-sufficiency plan and demonstration.

ACCOMPLISHMENTS

Concerted planning activities and technological accomplishments over the past 4 years have brought recognition and support to the Navy's energy R&D program. To illustrate this fact, the FY 1977-1981 Five-Year Development Plan (FYDP) provided for a $94 million RDT&E program. The FY 1978-1982 FYDP provides for a $163 million RDT&E program.

Thus far, as a result of the R&D effort, the Navy has identified areas for significant cost savings that will, in the future, enable the Navy to buy enough energy for its operational needs in spite of escalating energy costs. For example, preliminary projections indicate potential cost savings to the Navy of approximately $3 billion from FY 1978 through FY 1985, or 150 million BOE if the planned R&D effort is successful. These

figures do not yet constitute net savings. R&D work must be continued to determine net savings and to permit prioritizing for funding application under limited budget constraints.

The Navy Energy R&D Program Plan is the culmination of all the planning efforts to focus and refine energy R&D activities for the most efficient use of RDT&E funds.

Technological achievements have been significant. Only a brief summary is presented here.

Energy Conservation

The Navy began its energy conservation efforts as early as 1972 when ASN(R&D) recognized the energy crisis that would result from petroleum fuel supply disruptions. As the result of an assessment made in 1972 of the impact and the definition of Navy response to an anticipated crisis in the availability of fuel, the Navy began to formulate procedures for saving energy. When the President in mid-1973 called for a 7 percent reduction in the use of energy by the federal government, the Navy responded with a 20 percent reduction in FY 1974.

To date, the principal result of the Navy's energy conservation effort has been in reducing wastefulness in the use of energy. Additional reductions will be achieved as R&D efforts and capital investment lead to equipment modifications and developments in ships, aircraft, and shore facilities. Progress has been made in these areas, and there have been several significant achievements:

- Seawater cooling at one Navy coastal facility has been determined to be both technically and economically feasible.
- Plans are well developed for improving thermal efficiency and reliability of power generation equipment. Principal thrusts are in the selection of total/selective energy systems for Navy applications, low-temperature heat-recovery power systems where a Rankine bottoming cycle system is about to be tested, and measurement of energy losses in pipelines.
- The definition of thermal and operations and maintenance (O&M) properties of available building materials is nearly completed.
- Experimental lighting control systems that automatically maintain specified lighting levels and account for natural daylighting have been developed and tested.
- Attributable cost savings have been determined for an installed, experimental, energy monitoring and control system (EMCS).
- An economic payback methodology has been developed for determining optimum mixtures of power systems and energy conservation devices at Navy bases. In the future, computers will be used for more efficient sensitivity analyses.
- Statistics related to energy consumption are being acquired and analyzed. Energy by end-use category was determined for the Pacific Missile Test Center, and a methodology was developed to categorize end use of energy at other Navy facilities.

- A three-phase study is under way to determine the best way to convert from oil and natural gas to coal in electric power and steam generation systems at Navy bases.
- Baseline performance efficiency and life-cycle costs of propulsion, ship's services, electrical, and major auxiliary subsystems for future ships and craft have been analyzed. Fully automated routines for analyzing total energy systems and life-cycle costs have been developed.
- Energy-related design parameters and energy consumption characteristics of the major subsystems of destroyers and hydrofoils have been determined. Ninety propulsion systems and 48 ship's service electrical system alternatives have been synthesized.
- A program plan to analyze the energy intensiveness of major auxiliary system options has been developed.
- A study of destroyer lighting systems resulted in identification of several areas for shipboard suitability studies and cost analyses.
- The life-cycle cost computer model, completed during FY 1977, is being used to conduct detailed studies of those electrical and propulsion options that are energy conserving. Concepts meeting criteria for payback period and cumulative life-cycle savings have been recommended for further development.
- Destroyer hydronic pumping systems have been analyzed; cost analyses of several energy conserving options were also conducted.
- A contract was initiated to procure a Shipboard Total Energy Model (STEM) so that integrated energy studies of all shipboard systems can be conducted. A series of validating test cases has already been exercised.
- Underwater hull cleaning techniques are being developed. An interim fleet instruction on cleaning methods has been issued. Sea trials on four frigates to determine cost-effective cleaning frequency are continuing.
- Some organometallic-polymer-based paints have been delivered and are being evaluated to determine their potential as long-life antifouling hull coatings. Patch-panel static immersion tests and ship applications have started.
- Results of improved machinery alignment and operating procedures tests, conducted at sea in the U.S.S. Holt, indicate fuel consumption rates could be lowered significantly, particularly in the cruising range of the ship. Extension of analyses to other ship classes has begun.
- Water resource management studies and experiments are being conducted to improve the efficiency of freshwater production and utilization aboard ship. The cost of producing fresh water on ships has been determined. Techniques to reduce water consumption in galley, photo lab, laundry, and shower areas are being tested and evaluated.
- A pocket manual, "Conservation of Energy Aboard Ship," has been prepared and distributed to the fleet.

Synthetic Fuels

The Navy began investigating synthetic fuels in FY 1974. ERDA provided the Navy with 1,238 barrels of synthetic crude from FMC's Char-Oil Energy Development (COED) pilot plant for test and evaluation under the SEACOAL project. Successful completion of preliminary tests on the distilled crude culminated in a sea-trial demonstration in the U.S.S. Johnston. The results of these tests indicated that the characteristics of COED process synthetic fuel are similar to those of conventional, petroleum-based fuels used in Navy boilers. It was later determined that the COED crude could also be a potential source of jet fuels provided additional processing was achieved.

In 1974, the Army, Navy, Air Force, Maritime Administration (MARAD), Coast Guard, NASA, and ERDA established a joint project to evaluate shale oil products. Results of many tests indicated that, in a majority of cases, the performance characteristics were within the normal range for the particular hardware used in the tests. The tests culminated in a flight of a T-39 executive jet by the Air Force; the successful cruise of the steamer Edward B. Green, sponsored by the Navy, MARAD, and Coast Guard; and the operation of a jeep by the Army. Tests demonstrated the feasibility of using crude shale oil as a feedstock for military fuels.

A new project was started in 1976 to refine 50,000 to 100,000 barrels of shale oil crude into a spectrum of military specification fuels in a typical commercial-scale refinery. These products will be tested by the Army, Navy, Air Force, NASA, and DOE to determine the performance and compatibility with military equipment.

Preliminary tests were conducted in FY 1975 with "Unifined Kerosene" from Canadian tar sands that had the same characteristics as JP-5.

As a result of the research done to date, the Navy has concluded that a significant portion of its midterm (1985-2000) energy needs can be supplied by synthetic fuels.

Energy Self-sufficiency

In its energy self-sufficiency efforts, the Navy is developing the capability to use local, renewable energy sources at both remote and domestic bases, and where possible, to replace liquid hydrocarbon fuels at domestic bases with more abundant fuels, such as coal. The Navy's self-sufficiency efforts began in FY 1973, and have resulted in several significant R&D accomplishments:

- CEL has been testing and evaluating various solar collectors. A solar design manual was published in FY 1976.
- A study was completed in early 1977 that defined the potential of solar air conditioning for lowering energy costs.
- Conceptual designs were completed for a solar-electric turbine generator that appears to have economic potential. Work is being done in conjunction with the Electric Power Research Institute (EPRI) and ERDA.

- Geophysical studies during 1976 and 1977 have resulted in the selection of a drilling site on Adak for a geothermal well for heating, power generation, or both. This well could pay for itself in 8 years.
- Exploratory work, with ERDA support, has resulted in an active program to develop the geothermal potential at the Coso range at NWC, China Lake. The drill rig for the first well is on site.
- The Navy is supporting and encouraging the development of geothermal resources at the Naval Ammunition Depot (NAD), Lualualei on Oahu, Hawaii, to provide electrical power to the depot.
- Studies have shown that the conversion of wind energy to electricity has high potential at a number of Navy installations. CEL has been conducting field experiments on a 5-kw generator since FY 1976.
- The Navy is supporting utilization of waste materials in three areas: evaluation of packaged heat-recovery incinerators, handling and burning tests of refuse-derived fuel (RDF), and, in conjunction with the Environmental Protection Agency (EPA), conversion of solid waste to gasoline. In the latter case, a 100-ton-per-day plant appears to be economically attractive at gasoline prices above $0.42 per gallon.
- The Navy is providing siting and management support for ERDA's fluidized-bed boiler demonstration at Great Lakes.

MANAGEMENT RELATIONSHIPS

To achieve its energy R&D goals, the Navy has established working relationships with the management groups of other DOD components and energy-related federal agencies. Accomplishment of the Navy's R&D tasks requires various degrees of participation with and cooperation among the other organizations conducting energy R&D. These agencies and the Navy's interactions with them are an essential part of the Navy's plan and critical to the attainment of its goals.

At the national level, ERDA and the Federal Energy Administration (FEA) provide assistance in promoting national energy concern and developing specific incentives needed to achieve specific U.S. energy goals. These incentives include encouraging maximum private-sector involvement; initiating energy research, development, and demonstration (RD&D) efforts when the private sector is unable to achieve national goals; and establishing a consistent developmental regulatory framework that balances the early development of alternative technologies with other legitimate public needs such as human health, safety, environmental protection, and economic regulation. To establish the basis for cooperation in national energy and energy-related projects, ERDA and DOD signed a Memorandum of Understanding (MOU) on 15 January 1977. This MOU delineates the rationale for a cooperative effort between ERDA and DOD and defines the policies and procedures for collaborating in the development of nonnuclear energy sources.

Navy work with ERDA and other government agencies involves a number of energy and energy-related R&D activities. Currently, the Navy is participating in more than 25

interagency agreements for the mutual benefit of the Navy and the agencies being assisted. A number of joint efforts have been initiated as the result of the close cooperation between the Navy and ERDA. One such project is a major study of energy conservation to be conducted at Sewells Point Naval Complex, Norfolk, Virginia. This project will be funded by ERDA and carried out by a contract administered by NAVFAC. Another ERDA-DOD project, authorized by Congress, involves the installation and evaluation of solar heating and cooling units in housing at Army, Air Force, and Navy installations in the United States. Again, ERDA is funding the project and the Services are supplying the test facilities.

The Navy has also reached agreement with ERDA to use the Great Lakes Public Works Center (PWC) as a demonstration site for a fluidized-bed boiler. Cooperative programs also exist in the use of Rankine bottoming cycles for diesel power plants and in the demonstration of seawater as a cooling fluid in air-conditioning systems. The Navy is assisting ERDA in research on the use of ocean thermal gradients as an energy source by making Navy specialists available as consultants in ocean technology and engineering.

Within DOD, numerous offices, committees, and ad hoc groups have been organized in response to various aspects of the energy problem. As the energy problem became more generally recognized and these new organizations were formed, the Navy became more directly involved as it responded to DOD requests for energy-related data. The Navy now has representation on the following DOD committees:

- Defense Energy Policy Council.
- Defense Energy Action Group.
- Defense Energy R&D Coordination Committee.

These committees and the Navy's participation on them are described in Chapter 6.

In the Department of the Navy, energy matters are coordinated with the Special Assistant for Energy, ASN(R&D); Deputy Chief of Naval Operations (DCNO) (Logistics), OP-04; Director, RDT&E, OP-098; and the Assistant DCNM (Technology and Laboratories), MAT-08T. To assist OP-04 in its responsibilities, a Navy Energy Office (OP-413) was established in November 1976 as a central point of contact for all energy-related programs. This office is responsible for policy guidance and overall coordination of all matters pertaining to energy (except nuclear energy) and energy conservation. The Director, Navy Energy and Natural Resources R&D Office (MAT-08T3), is responsible for all energy R&D within the Navy. These offices all work closely together, coordinating continuously with each other.

1.0 INTRODUCTION

1.0 INTRODUCTION

The Navy Energy R&D Program Plan, defining a course of action for the Navy in solving its energy problems, is the principal management tool of the Director, Navy Energy and Natural Resources R&D Office. The plan, which covers FY 1978 through FY 1983, provides a structured approach to a well-integrated energy R&D program (exclusive of nuclear energy) and complements the Navy Energy Plan, developed by the Navy Energy Office (OP-413). Furthermore, the Navy Energy R&D Program Plan is integral with and supports the DOD and national energy programs.

Volume 1 of the plan consists of:

- Analysis of the Energy Problem (Chapter 2), which provides the basis for the plan, summarizing assessments made to develop solutions or approaches to the energy problems discussed.
- Development of the Energy R&D Program Plan (Chapter 3), which contains a description of the approach and logic used in developing the plan, then establishes the framework of energy R&D goals, strategies, and objectives upon which the program plan is based.
- *Synopsis of the Energy* R&D Program Plan (Chapter 4), which lists energy-oriented tasks being conducted by the Navy to support its goals. The list is divided into three sections: tasks by primary strategy (conservation, synthetic fuels, self-sufficiency) or other types of projects (energy-related support, management and analytical support, energy-related MOU projects), further subdivided by RDT&E Categories 6.1, 6.2, 6.3, 6.4, and 6.5; tasks by primary strategy and subject, such as HVAC systems, waste recovery, geothermal, and wind projects; and funding by strategy and RDT&E category.
- Progress and Accomplishments (Chapter 5), which summarizes significant progress and accomplishments in the energy R&D program.
- Navy Energy R&D Management Relationships (Chapter 6), which presents the relationships and organizational responsibilities that are essential for the administration and management of the Navy energy R&D program.

Volume 2 includes:

- Appendix A, Patterns of Energy Usage in the U.S. Navy, used as the basis for applying planning principles in defining the R&D program plan.
- Appendix B, Navy Energy R&D Projects and Progress, which contains detailed descriptions, progress, and future plans for each energy project in the Navy's energy R&D program.

- Appendix C, National Energy Research, Development, and Demonstration Programs, which describes the national energy RD&D programs with which the Navy energy R&D program must interface.

For easy reference, an index is included in both volumes.

2.0 ANALYSIS

2.0 ANALYSIS OF THE ENERGY PROBLEM

2.1 ASSESSMENT OF THE NATIONAL ENERGY SITUATION

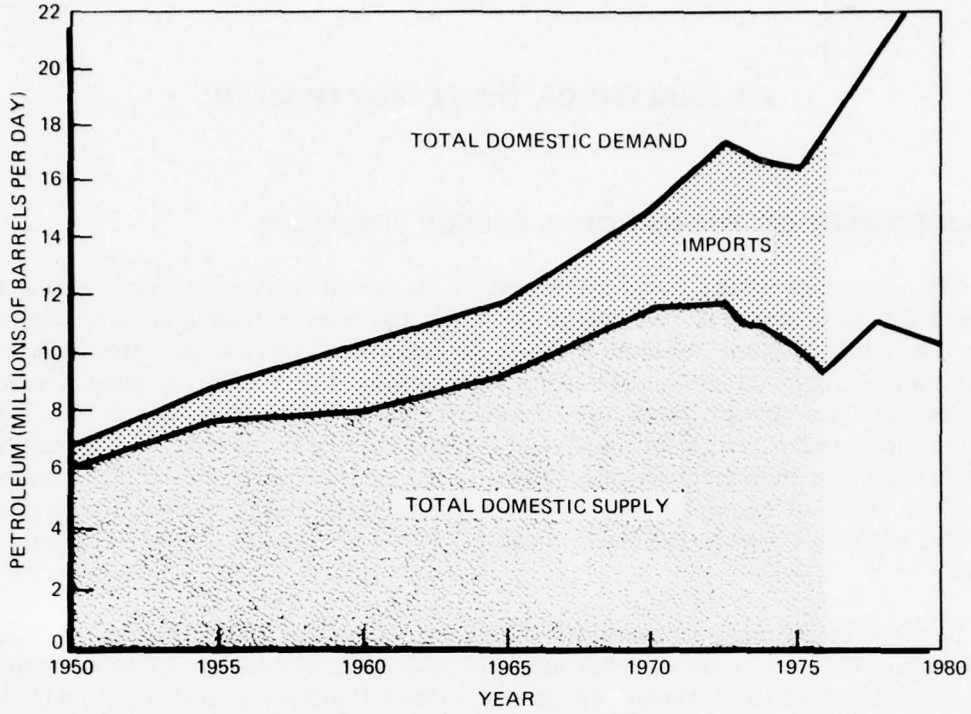
The economies of the world are geared to the use of petroleum products, and the demand for these products throughout the world has been increasing at unprecedented rates. The supply cannot continue to meet this demand, however; estimates show that world natural crude oil production will probably peak about 1990, creating a serious problem for both industrialized and developing nations. The inevitable result of the growing gap between petroleum supply and demand is easily predictable; the competition for the remaining petroleum supplies will be keen and the price will be high. Furthermore, the effect of the discrepancy between supply and demand on world geopolitical stability, while not readily calculable, could yield major shifts in the world balance of power.

In the United States, the energy situation has serious political, economic, and social implications. U.S. oil production has been declining since 1970. New recovery methods and new production from Alaska and the deep Outer Continental Shelf (OCS) will slow or reverse the decline for a short time, but will not satisfy the projected growth in U.S. demand. (To maintain petroleum reserves at the present level, the United States would need to discover the equivalent of another Prudhoe Bay, Alaska, oil field each year.)

To meet the increasing domestic demand, the United States has had to import increasing amounts of oil. (See Figure 1.) In January and February 1977, the United States imported about 9 million barrels of oil per day, half of the total domestic consumption.[1] To lessen its heavy dependence on foreign oil, the United States has several alternative solutions. Short- and medium-term solutions are to decrease the wasteful use of energy (although conservation alone will only marginally extend the date when U.S. oil reserves will be depleted) and to develop other, more abundant resources.

Another, longer term solution is the development of a commercial synthetic fuels industry and of renewable and essentially inexhaustible energy sources, such as solar and geothermal. Effecting such solutions is dependent on a number of related variables, not the least of which are political, economic, and institutional obstacles. Until such solutions can be effected so that the United States can achieve an acceptable degree of energy self-sufficiency, ***there is a clear and serious threat to the security of the United States stemming from the growing deficiency of secure energy resources.***

[1] "The National Energy Plan," 29 April 1977.



SOURCE: *National Energy Outlook 1976,* February 1976, Page xxiii.

Figure 1. DOMESTIC PETROLEUM PRODUCTION AND DEMAND

2.2 ASSESSMENT OF THE DOD ENERGY SITUATION

National security and defense rely heavily on portable fuels to support worldwide commitments on the ground, in the air, and on the seas. In 1976, for example, DOD, the nation's largest single user of energy, consumed about 210 million BOE, or 1.7 percent of the total U.S. demand for energy of 12.6 billion BOE. Of the energy used by DOD, 68 percent was in the form of petroleum. (DOD uses about 3 percent of total U.S. petroleum consumption.) The Air Force is the largest petroleum user, consuming 53.3 percent; the Navy uses 36.5 percent, and the Army, 10.2 percent.

In FY 1976, DOD required an appropriation of $3.7 billion for energy alone, which represented 4 percent of DOD's total budget and 13 percent of its O&M budget. Future price increases will further tend to reduce the availability of fuel for operational readiness and training. Furthermore, in the event of a national shortage of liquid hydrocarbon products, accompanied by industrial slowdown, unemployment, and hardship throughout the country, the allocation of fuel to the Armed Forces through implementation of the Defense Production Act may not be economically or politically acceptable. Any national

shortages of natural gas or electricity will also severely affect DOD facilities and installations.

DOD can, to a certain extent, substitute alternative energy sources, such as coal, oil shale, geothermal, solar, and nuclear power. Currently, however, few military bases use the nation's more abundant energy resources such as coal and oil shale. ***There is therefore a need to convert where possible to the direct use of coal as a boiler fuel for shore facilities.***

With the exception of operating bases and facilities located within the United States, DOD's energy options are limited. Military operations and transportation of military materials, weapons, and supplies now, and will in the future, depend almost completely on petroleum.

2.3 U.S. NAVY ENERGY SITUATION

2.3.1 Assessment of Energy Usage Trends and Costs

An understanding of historical and projected energy-use patterns is fundamental to the development and implementation of a Navy energy R&D program. Therefore, Navy energy usage patterns have been analyzed (Appendix A). The analysis, updated annually, provides a baseline against which future energy requirements can be predicted as a function of force levels and operating tempos.

Predictions based on the Navy energy usage profile clearly indicate that, over the next 25 years, the requirement for liquid hydrocarbon fuels will increase as the current and projected ships, aircraft, and weapon systems continue to rely on this source of energy. As shown in Figure 2, energy usage decreased sharply from 1975 to 1976, reflecting declining fleet strengths, reduced operating tempos, increasing energy prices, and the initiation of energy conservation efforts. The increase in energy consumption shown for FY 1977 reflects a partial return to operating tempos required to maintain fleet readiness. There should be a decrease in the Navy use of energy through FY 1980 as ship, air, and shore conservation techniques, such as improved hull cleaning methods, use of improved hull coatings, and use of flight simulators, are implemented. Energy demand will then increase as a result of introducing new ships into the fleet. Shore energy use will continue to decrease as conservation efforts now under way and planned are implemented. In later years, however, increasing use of shore-based "Cold Iron" support to ships and simulators will cause shore energy consumption to increase. This increase in energy demand (Figure 2) combined with an estimated 3 percent annual increase in fuel prices will mean that the cost of Navy energy, which was $1.2 billion in 1976, will increase to $2.8 billion (in 1976 dollars) by 2000. ***Increasing fuel costs will continue to have a significant impact on Navy sea, air, and shore-based operations.***

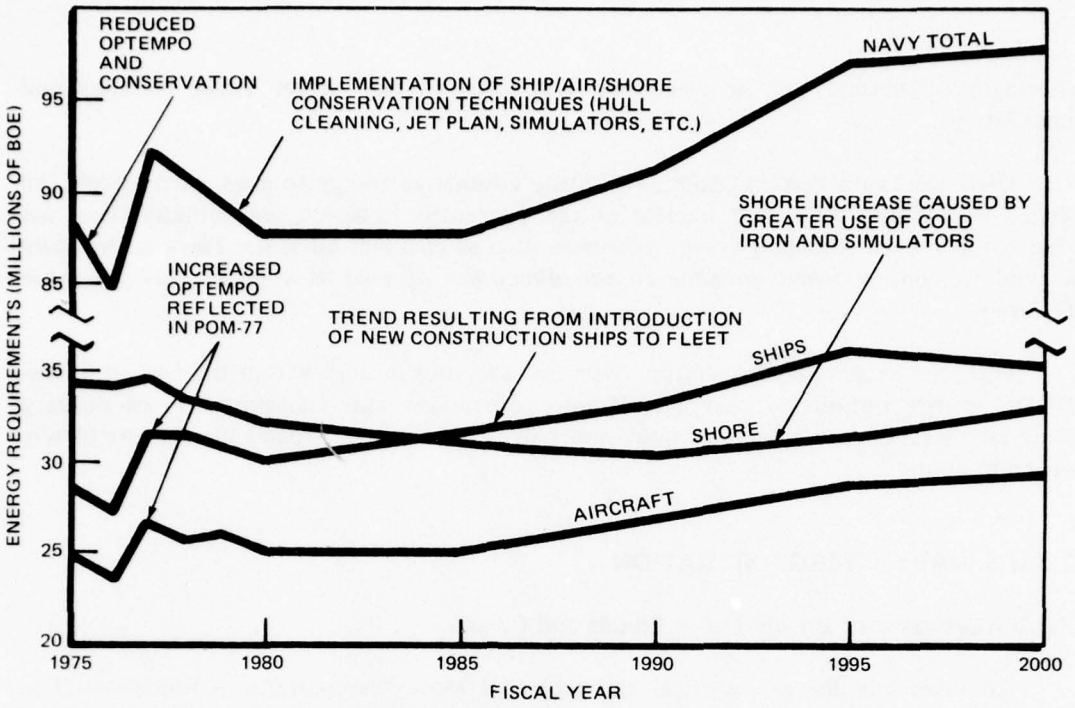


Figure 2. NAVY ENERGY REQUIREMENTS, 1975-2000

2.3.2 Assessment of Methods to Reduce Energy Consumption Without Adversely Affecting Fleet Readiness

The results of an analysis of the latest Navy energy usage profile show that the Navy significantly reduced energy use between FY 1973 and FY 1976. The cumulative savings amounted to 44.6 percent for ships, 14.5 percent for aircraft, and 12.7 percent for shore facilities. A large portion of the reduction for ships and aircraft was achieved by a marked reduction in operations. For example, during the same fiscal years, there was a 32.6 percent reduction in underway steaming hours for ships and a 19.6 percent reduction in flight activity. While such conservation measures were necessary to meet the immediate crisis, this kind of conservation can be pursued only for short periods without experiencing a loss of training effectiveness and, ultimately, fleet readiness. Therefore, for the long term, methods of reducing energy consumption that do not compromise the readiness and the overall cost-effectiveness of the Navy must be found. The more obvious ways of achieving this balance involve a twofold approach to the problem:

- Develop and implement new technologies, operating practices, or both that will reduce energy consumption by eliminating losses now incurred without losing effectiveness.
- Develop new propulsive and nonpropulsive machinery having a higher basic efficiency than current systems.

Energy conservation technology must be developed so that energy use can be reduced without adversely affecting fleet readiness and training.

2.3.3 Assessment of the Potential of Using Alternative Fuels for the Navy

The potential alternatives to petroleum-based fuels for ships and aircraft are a matter of much speculation. Possible alternative fuels are:

- Hydrogen.
- Alcohols.
- Nuclear power.
- Synthetic fuels.

Hydrogen has a high gravimetric heating value (51,500 Btu per pound compared with 18,000 Btu per pound for typical hydrocarbons). Hydrogen has efficient nonpolluting combustion properties, and can be synthesized from water and any available high-quality energy source. However, it also has a low volumetric heating value (30,000 Btu per gallon compared with 130,000 Btu per gallon for typical hydrocarbons). Because of the low temperature needed to store it in liquid form, hydrogen storage tanks must be insulated and would have to be about four times the volumetric size of those required to hold a similar quantity of energy in hydrocarbon form. Studies indicate that ***use of liquid hydrogen for ships and military aircraft will not be technically or economically attractive for at least several hardware generations.***[1]

Other alternatives are alcohols—methanol, ethanol, propanol, and butanol. These can be manufactured from coke, coal, wood, or municipal waste, and unlike hydrogen, can be stored in liquid form at normal temperatures. However, the energy density of alcohols does not compare favorably with that of conventional petroleum fuels; alcohols contain less than half the energy per pound or per gallon. Furthermore, alcohols have a low flash point and are water soluble. ***Because of low energy density and other negative characteristics, alcohols are not practical as fuels for aircraft, and on ships their use would necessitate significant increases in ship size for the same range-payload performance.***[2]

Nuclear-powered ships can move at high speeds over long distances without logistic support. On a life-cycle cost basis, large nuclear-powered ships are economically competitive with their petroleum-fueled counterparts. Because of the advantages of nuclear propulsion, Congress, in its Defense Authorization Bill for FY 1975 (P.L. 93-365), established a policy that nuclear propulsion would be provided for major combatants built for naval strike forces. (Subsequent authorization bills may or may not continue that policy.) However, nuclear propulsion has not been shown to be practical for smaller surface vessels or for high-performance, weight-limited craft. Nuclear power plants with a lower specific weight (for example, those having high-temperature, gas-cooled reactors) have been suggested; however, none has yet been developed that will satisfy the requirements for propulsion systems for small- and medium-size ships. Development of a lightweight nuclear power system for small- and medium-size craft will require a consider-

[1] Hardware generation is defined as a period of time during which the basic design concept remains unchanged.

[2] B. Berkowitz, et al., "Alternative, Synthetically Fueled Navy Systems: Force Element Missions and Technology," DDC No. AD/B-001 4001, General Electric Company–TEMPO, November 1974.

able research effort. ***Thus, for technical and economic reasons, small- and medium-size surface ships will most likely rely on liquid hydrocarbon fuels for the near future.***

Synthetic fuels derived from coal, oil shale, and tar sands have a great deal of potential as alternatives to petroleum-based fuels. Furthermore, the United States has a vast abundance of the raw materials needed for producing synthetic fuels. A comparison of Figure 3 with Figure 4 shows that the U.S. share of hydrocarbon deposits (37.9 percent) is considerably larger than its share of recoverable crude oil (5.2 percent). U.S. oil, gas, coal, oil shale, and tar sands resources are delineated in Table 1. If properly developed, these resources could well sustain the projected petroleum demands of the United States for more than a century.

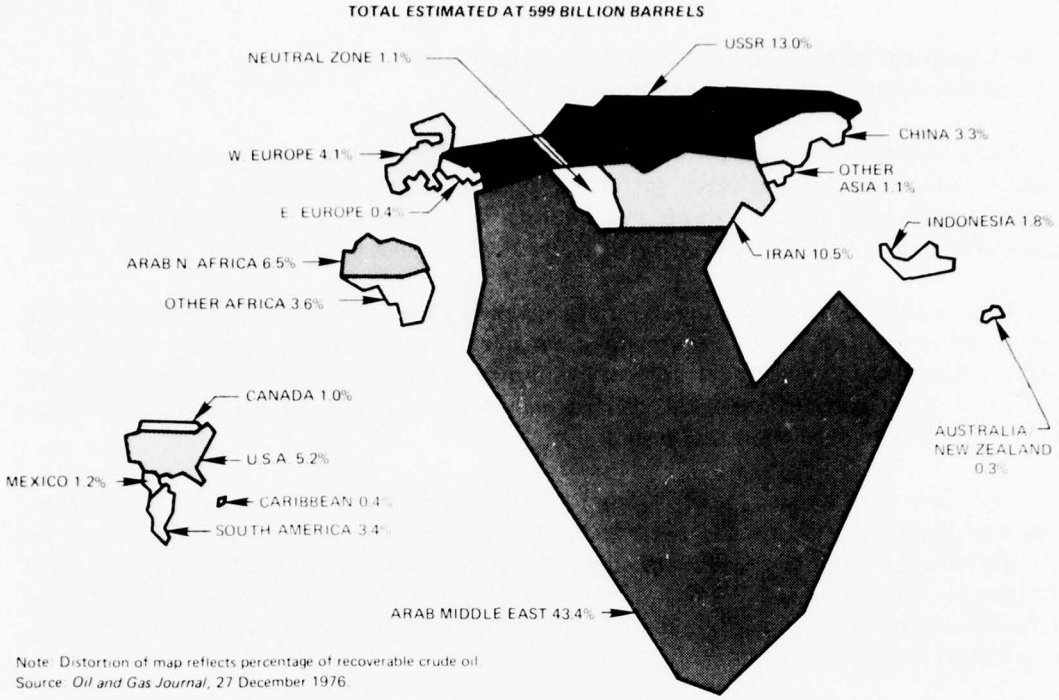
Table 1. SUMMARY OF U.S. ENERGY RESOURCES

Energy Source	Resources (Billions of BOE)
Crude oil	113
Natural gas	94
Coal	16,778
Shale oil	2,200
Tar sands	27
Total	19,212

Conversion technologies for producing liquid products from oil shale and coal have been demonstrated, and a commercial-scale tar sands plant is in operation (in Canada). The goal of current R&D programs is to improve the conversion technology and reduce the cost of the synthetic fuels. Generally, the R&D efforts for improved synthetic fuel processes are at the pilot-plant stage; construction of coal, oil shale, and tar sands process plants on a commercial scale is being delayed by capital requirements, legal restrictions, and environmental constraints. It is estimated, however, that sizable quantities of synthetic crudes could become available in the 1980s, initially from domestic oil shale and eventually from coal and tar sands.

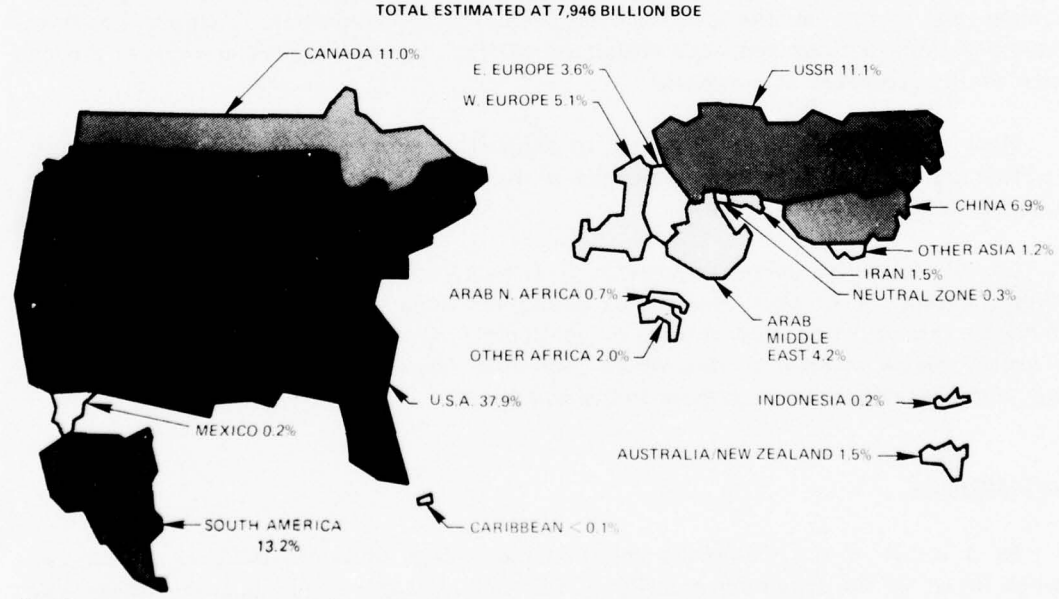
The Navy has been investigating the potential of using synthetic fuels as alternatives to petroleum-based fuels, since ***synthetic fuels derived from oil shale, coal, and tar sands offer the best long-term assurance of naval fuel availability from domestic resources other than nuclear energy***. Furthermore, the use of synthetic fuels, rather than other alternative fuels such as hydrogen and methanol, eliminates the substantial logistic problem of maintaining two different fuel supply systems during the 25- to 30-year transition period.

Only synthetic hydrocarbon fuels and nuclear power will be able to replace petroleum-derived fuels before the turn of the century. Since most ships and aircraft, of economic necessity, have relatively long lifetimes, and since nuclear power is currently planned only for submarines and large surface ships, ***liquid hydrocarbons will continue to be the primary fuels required by Navy aircraft and most surface ships through the turn of the century***.



Note: Distortion of map reflects percentage of recoverable crude oil.
Source: *Oil and Gas Journal*, 27 December 1976.

Figure 3. WORLD RECOVERABLE CRUDE OIL



Note: Distortion of map reflects percentage of recoverable fossil fuel.
Source: *Oil and Gas Journal*, 27 December 1976; 1974 World Energy Conference; and U.S. Bureau of Mines, 1976.

Figure 4. WORLD RECOVERABLE FOSSIL FUEL: AGGREGATE OF OIL, NATURAL GAS, COAL, OIL SHALE, AND TAR SANDS

2.3.4 Assessment of Methods to Reduce the Dependency of Navy Bases and Forces on Petroleum Fuels

Naval shore facilities used 18.9 percent (11.5 million barrels) of the liquid petroleum products consumed by the Navy in FY 1976. As alternative sources of energy become available, however, selected shore installations will become less dependent on liquid hydrocarbon fuels. The petroleum saved could then be diverted to support mobile forces.

The technologies for tapping a variety of energy sources are being developed by the federal government. ERDA, for example, is developing geothermal, solar, wind, solid waste, ocean sources, and direct coal utilization technologies. ERDA-sponsored wind and solar projects, in particular, should lead to technological improvements that will provide more cost-effective systems in the near future.

The Navy can benefit directly from participating in federal programs for development and demonstration of advanced technologies. Some of these R&D projects will be federally funded with the Navy providing the demonstration sites, planning, and R&D management support. (The Navy has been surveying sites to determine the potential of alternative energy sources for use at its facilities.) Others may be jointly or independently funded Navy projects.

Providing alternative energy sources for base requirements or reducing the fuel consumption of the base will not alone make the base more energy self-sufficient. Using a local power source also does not significantly reduce the petroleum and fuel logistics requirements except in the case of very remote, special-purpose facilities (such as communications stations and radar installations) that require a limited amount of power, either locally generated or purchased.

Most remote bases exist primarily to support fleet naval and air forces and must therefore be supplied with large quantities of fuel. The long supply lines to the remote bases are strategically vulnerable.

Use of alternative energy sources, such as solar, wind, geothermal, or ocean sources, requires a trade-off between the cost of developing these local resources and the cost of purchasing, transporting, and storing conventional fuels. ***This trade-off, however, should be heavily biased in favor of developing alternative renewable energy sources to achieve long-term self-sufficiency for remote forces and bases.***

2.4 FINDINGS

As a result of the worldwide and national energy situation, there is a clear and serious threat to the long-term security of the United States stemming from the growing deficiency of secure energy resources. The energy situation has several effects on the Navy:

- Increasing fuel costs will continue to have significant impact on Navy sea, air, and shore-based operations.
- The Navy should convert, where possible, to the direct use of coal as boiler fuels for shore facilities.
- Energy conservation technology must be developed so that energy use can be reduced without adversely affecting fleet readiness and training.
- The use of liquid hydrogen for ships and military aircraft will not be technically or economically attractive for several hardware generations.
- Because of their low energy density and other negative characteristics, alcohols are not practical fuels for use by aircraft or ships.
- For technical and economic reasons, small- and medium-size surface ships will most likely rely on liquid hydrocarbon fuels for the near future.
- Synthetic fuels derived from oil shale, coal, and tar sands offer the best long-term assurance of naval fuel availability from domestic resources.
- Liquid hydrocarbons will continue to be the primary fuels required by Navy aircraft and most surface ships through the turn of the century.
- The near-term trade-off between conventional fuels and alternative fuels should be heavily biased in favor of developing renewable energy sources to achieve long-term self-sufficiency for remote forces and bases.

3.0 DEVELOPMENT OF THE ENERGY R&D PROGRAM PLAN

3.1 METHODOLOGY

3.1.1 Energy Data Base

Since the establishment of the Navy Energy and Natural Resources R&D Office (MAT-08T3), a comprehensive energy data base and program plan have been developed. Both the data base and program plan have been continuously updated as new policies have been defined and new tasks initiated. As shown in Figure 5, elements considered in the development of the Navy Energy R&D Program Plan include:

- National and DOD energy cost, supply, and demand data.
- Navy energy usage patterns and projections.
- Energy technology state-of-the-art.
- National energy technology goals.
- DOD energy R&D goals and guidelines.
- Navy energy goals, strategies, and policies.
- National energy RD&D programs.
- Current Navy R&D energy program status.
- Capabilities of Navy laboratories and facilities.

National and DOD energy cost, supply, and demand data have been gathered from both the government and industry. The principal publications are "The National Energy Plan," signed by the President on 29 April 1977; "A National Plan for Energy Research Development and Demonstration: Creating Energy Choices for the Future," ERDA, April 1976; energy resource assessments by the U.S. Bureau of Mines; special energy economics reports prepared by the Chase Manhattan Bank; and "Department of Defense Energy Initiatives Plan," 24 November 1976.

Navy energy usage patterns and projections (shown in Appendix A) are based on the energy profile prepared by the Naval Ship Research and Development Center (NSRDC), Annapolis, for the Navy Energy R&D Office. Energy technology state-of-the-art is summarized in ***Energy Fact Book--1977***, published by MAT-08T3, and in the technology descriptions (provided in Appendix B) included in the various projects and task reports from the SYSCOMs and Navy laboratories. National Energy RD&D programs are included in the ERDA national plan and are summarized in Appendix C.

3.1.2 Analysis of Data

As the data base was developed, the data were analyzed to assess:

- National and DOD energy situations.

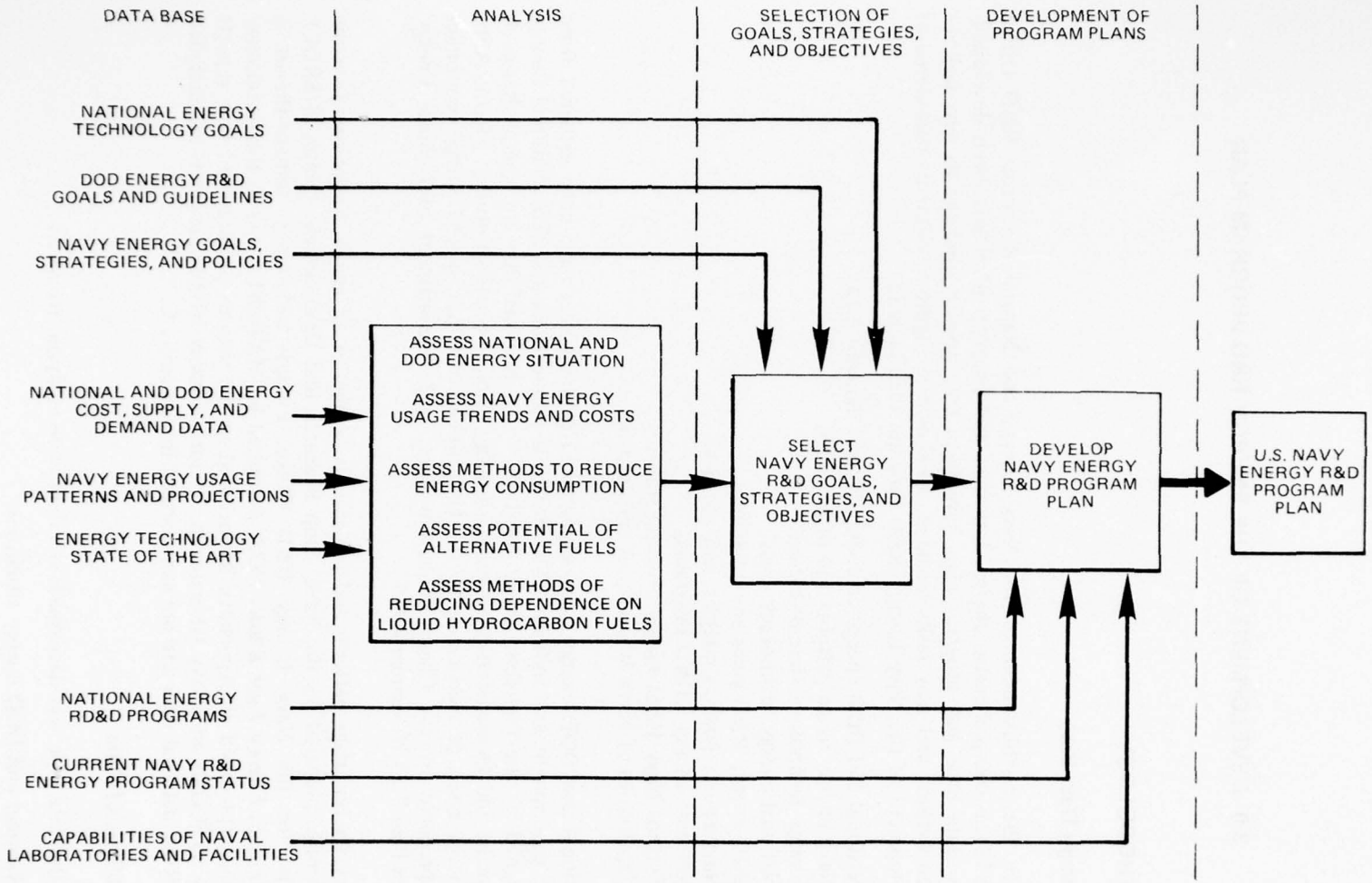


Figure 5. METHODOLOGY—NAVY ENERGY R&D PROGRAM PLAN

- Navy energy usage trends and costs.
- Methods to reduce energy consumption without adversely affecting fleet readiness.
- Potential of using alternative fuels for the Navy.
- Methods to reduce the dependency of Navy bases and forces on liquid hydrocarbon fuels.

3.1.3 Selection of Goals, Strategies, and Objectives

Based on these assessments, specific Navy energy R&D goals, strategies, and objectives were selected:

- A technological goal is the broadest possible statement defining R&D aims that can be effected with respect to the prescribed mission of the Navy.
- A strategy is one of several approaches that has been selected as a means of meeting the R&D goals of the Navy.
- An objective is a specific end point or position to be attained.

The specific goals, strategies, and objectives provide a framework within which the Navy's energy R&D policy and program guidance is formulated.

3.1.4 Development of Navy Energy R&D Program Plans

Initially, the Navy energy R&D program comprised ongoing work funded before the energy crisis of 1973. Since structured Navy energy R&D goals and strategies were established in 1974, these tasks have been refined and new tasks added to meet specific energy R&D objectives. Today, the tasks represent all categories of energy R&D work and are part of a comprehensive, well-organized energy R&D program plan.

This program plan is reviewed and modified continually to reflect the Navy's newest R&D efforts, which change from year to year, and to make optimal use of available funds. Based on MAT-08T3 guidance, SYSCOM program descriptions are updated semi-annually, although more frequent changes may be made as necessary.

3.2 NATIONAL ENERGY GOALS AND STRATEGIES

"The National Energy Plan" was presented to Congress by the President on 20 April 1977. The objectives of this plan are:

- In the short term, to reduce dependence on foreign oil and limit supply disruptions.
- In the medium term, to weather the eventual decline in the availability of world oil supplies caused by capacity limitations.
- In the long term, to develop renewable and essentially inexhaustible sources of energy for sustained economic growth.

The President announced the following goals to be achieved by 1985:

- Reduce the annual growth of total energy demand to below 2 percent.
- Reduce gasoline consumption 10 percent below its current level.
- Reduce oil imports from a potential level of 16 million barrels per day to 6 million, roughly one-eighth of total energy consumption.
- Establish a strategic petroleum reserve of 1 billion barrels.
- Increase coal production by two-thirds, to more than 1 billion tons per year.
- Insulate 90 percent of American homes and all new buildings.
- Use solar energy in more than 2.5 million homes.

The major strategies for reaching these goals are:

- Implementation of an effective conservation program for all sectors of energy use to reduce the rate of demand growth to less than 2 percent, thereby helping to achieve both the short- and medium-term goals.
- Conversion of industry and utilities using oil and natural gas to coal and other more abundant fuels to reduce imports and make natural gas more widely available for household use, thereby helping to achieve both the short- and medium-term goals.
- A vigorous research and development program to provide renewable and essentially inexhaustible resources to meet U.S. energy needs in the next century, thereby helping to achieve the long-term goal.

3.3 DOD ENERGY R&D GOALS

The DETG, in its Phase II report, recommended several energy goals for DOD. These goals, approved by the Secretary of Defense on 26 August 1974, are to:

- Determine the defense energy R&D program that will contribute the most to national defense, including meeting worldwide security agreements, especially during oil embargoes, limited wars, and the possible interdiction of the supply of energy in the form of oil or liquid natural gas (LNG) to the United States and the supply of fuel to conduct possible future military operations in Europe (with NATO allies), the eastern Mediterranean, the Middle East, and South America.
- Determine if R&D efforts can open new options that are valuable in efforts to maintain a dependable supply of energy overseas to meet commitments there and to conduct such military operations as may be necessary. Identify, describe in detail, evaluate, and set priorities for the candidate defense energy R&D programs.
- Determine what defense energy R&D, as distinct from existing and planned civil agency R&D, could do to minimize the impact of oil embargoes on CONUS (continental United States) military capabilities. In addition, identify, describe, and evaluate candidate energy R&D projects, such as the operation of aircraft and ships on refined petroleum products made from coal and oil shale, to minimize U.S. dependence on oil imports.

- Identify, describe, and evaluate those defense energy R&D programs that could lead to fuel conservation with a reduction in operational fuel costs, and that would return the investment required within 3 years.
- Identify those energy-related R&D programs that are funded primarily for military reasons such as improved efficiency in aircraft, ship, and vehicle propulsion but that might have some secondary energy benefit although it cannot be justified on the basis of dependable energy or reduced costs.

In addition to these goals, supplementary guidance applicable to DOD energy RDT&E was provided:

- Concentrate on DOD missions and needs.
- Concentrate on areas of major payoff.
- Give high priority to natural hydrocarbon fuel conservation and synthetic fuel utilization.
- Maintain knowledge of civil agency energy R&D.
- Encourage incorporation of DOD requirements into civilian programs.

3.4 NAVY ENERGY GOALS

The Navy's energy goals, as approved by the CNO on 26 January 1977, are to:

- Begin the transition from depending on natural petroleum fuels to using alternative energy sources, where possible.
- Reduce the Navy's reliance on foreign energy supplies.
- Increase the efficiency and reliability of the Navy's energy-dependent systems without compromising flexibility, readiness, or performance.
- Establish a cooperative working relationship with national and international agencies to achieve national energy goals, and assist in reducing the nation's vulnerable position to actions by foreign suppliers to disrupt energy flow.
- Minimize the penalties imposed on the Navy's operations that are caused by increased fuel prices.
- Determine the necessary steps to be taken to continually ensure the Navy's energy future, especially in the event of oil embargoes, limited wars, and limited interdiction of U.S. and allied fuel supplies.
- Establish quantifiable energy conservation goals:
  - Mobile operations (ship, aircraft, and vehicles) will maintain total nonrenewable energy use at the consumption rate established during FY 1975.
  - Shore facilities (utilities) will reduce energy consumption 15 percent from the adjusted FY 1973 baseline.

3.5 SELECTION OF NAVY ENERGY R&D GOALS AND STRATEGIES

Within the guidelines provided by the national, DOD, and Navy energy goals, and based on an assessment of the technological data, Navy energy R&D goals and strategies were selected.

The Navy's energy R&D goals are to reduce its dependence on foreign energy supplies and minimize the impact of increasing fuel prices on Navy operations. Important considerations regarding these goals are that:

- Ships now in operation and in the shipbuilding program will constitute the force structure of the Navy through the turn of the century. Unless these ships are modified extensively, which would be extremely costly, liquid hydrocarbons will continue to be the primary fuel well into the twenty-first century.
- Since fuel used by Navy vessels and aircraft represents a small percentage of the national energy consumed, the Navy's R&D costs to develop new propulsion concepts and alternative fuels would have to be amortized over a relatively small fuel saving. Although some of these developments might only be of benefit to the Navy, the cost can be justified on the basis of the project's effect on critical but nonquantifiable factors such as national security (fleet readiness and strength).
- Alternative fuels that will minimize the need for modifying or developing new propulsion plants must be developed.
- The selection of fuels and propulsion concepts for Navy vessels and aircraft will continue to be based on a combination of transport economics and military effectiveness factors.

To achieve its goals, the Navy is pursuing three R&D strategies:

- Energy conservation–eliminating wasteful usage of energy and developing more efficient designs for propulsion, power generation, and other energy systems so that less energy will be used.
- Synthetic fuels–promoting a viable federal program to establish a commercial-scale synthetic fuel production capability and conducting tests to ensure the compatibility of synthetic fuels with Navy equipment.
- Energy self-sufficiency–developing local renewable energy sources for use by remote and domestic bases and, where possible, replacing liquid hydrocarbons with more abundant fuels (such as coal) for use at domestic bases.

3.6 NAVY ENERGY R&D OBJECTIVES

The Navy energy R&D goals and strategies will be achieved through the accomplishment of the following objectives:

- Energy Conservation.
  - Develop, test, and evaluate shore-based systems that will use energy more efficiently.

- Develop, test, and evaluate present and future propulsion and auxiliary systems and hull-drag-reduction methods to achieve greater efficiency and cost-effectiveness in Navy vessels.
- Promote energy conservation through the continued development of equipment operation procedures and technical expertise and the distribution of engineering publications.
- Develop, test, and evaluate more energy-efficient aircraft systems (for both current inventory aircraft and advanced designs) and modifications in operational concepts, tactics, and equipments that will reduce fuel usage.

- Synthetic Fuels.
  - Determine characteristics of military fuels produced from synthetic crude.
  - Test, evaluate, and apply appropriate engineering expertise to ensure that synthetic fuels and Navy hardware are compatible.
  - Qualify synthetic fuels for Service use and issue specifications and fleet implementation guidelines.
  - Qualify nonspecification petroleum fuels for Navy use.

- Energy Self-sufficiency.
  - Test and evaluate energy systems that would be more self-sufficient, reduce the use of liquid hydrocarbons, or both.
  - Utilize renewable sources of energy such as combustible wastes; geothermal, wind, or solar power, or other available sources.
  - Select the most cost-effective sites and apply and demonstrate technology for energy self-sufficiency.
  - Promote energy self-sufficiency through continued development of technical expertise in energy systems and distribution of engineering publications.

4.0 SYNOPSIS OF THE ENERGY R&D PROGRAM PLAN

4.1 INTRODUCTION

The synopsis of the program plan is divided into three sections:

- Energy R&D projects by RDT&E Categories 6.1, 6.2, 6.3, 6.4, and 6.5.
- Energy R&D projects by subject.
- Funding.

RDT&E Categories 6.1 through 6.5, as defined in the Department of the Navy RDT&E Management Guide, 1 January 1975, are:

Category 6.1, Basic Research—Category 6.1 includes scientific study and experimentation directed toward increasing knowledge and understanding of the physical, engineering, environmental, biomedical, and behavioral-social sciences as they pertain to long-term, national security needs. Fundamental knowledge leading to the solution of identified military problems is obtained. The base for subsequent exploratory and advanced developments in defense-related technologies and for development of new or improved military functional capabilities is also created.

Category 6.2, Exploratory Development—Category 6.2 includes all efforts toward solving specific military problems, but does not extend into major development projects. This effort varies from fundamental, applied research to sophisticated, breadboard hardware, study programming, and planning efforts. However, the efforts *must* be directed toward specific military problem areas with the intent of developing and evaluating the feasibility and practicability of proposed solutions and determining their parameters. Exploratory development program elements are normally level-of-effort funded.

Category 6.3, Advanced Development—Category 6.3 includes all projects that have progressed into development of hardware for experimental or operational testing. The hardware is designed for testing or experimentation, and if successful, will be designed and engineered for eventual Service use. The projects are line item projects and are controlled on a project basis.

Category 6.4, Engineering Development—Category 6.4 includes development projects that are being engineered for Service use but that have not yet been approved for procurement or operation. These projects are major line items and are controlled on a project basis.

Category 6.5, Management and Analytical Support—Category 6.5 includes R&D efforts supporting installations or operations required for general R&D use, such as test

ranges, military construction, maintenance support of laboratories, operations and maintenance of test aircraft and ships, and studies and analyses in support of the R&D program.

Category 6.1 and Category 6.2 are block programmed and are administered by the Chief of Naval Research and the CNM, respectively. The SYSCOMs and laboratories are normally responsible for the planning and execution of work under Category 6.2. In the case of Category 6.2 energy conservation work, the Director, Navy Energy and Natural Resources R&D Office (MAT-08T3) administers and controls the block funding. Category 6.3 and Category 6.4 are administered by the Director, RDT&E (OP-098). In energy matters, supervision of this effort is delegated to the CNM and MAT-08T3, who authorize the implementation of energy projects at the SYSCOMs. Category 6.5 projects are supervised by MAT-08T3.

Figure 6 shows the three Navy energy R&D strategies, which will be outlined in this chapter, together with two supporting functions–energy-related support and management and analytical support–and a third function–energy R&D done for other agencies under MOUs. This line diagram will be repeated both in this chapter and in Appendix B, indicating the area of work under discussion at that point. Appendix B contains a more complete description of each work unit or project, including objective, technical approach, progress, and planned milestones.

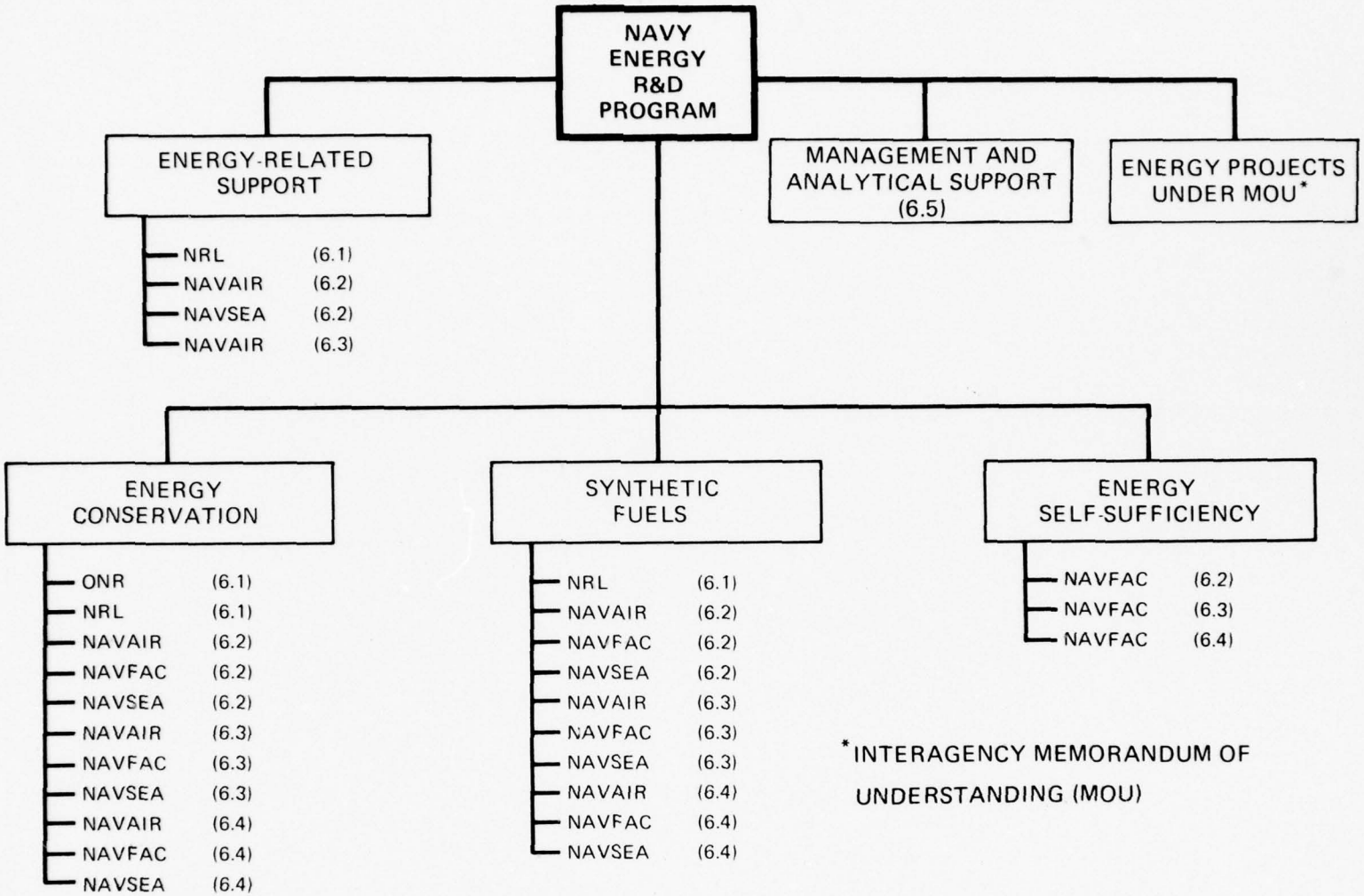
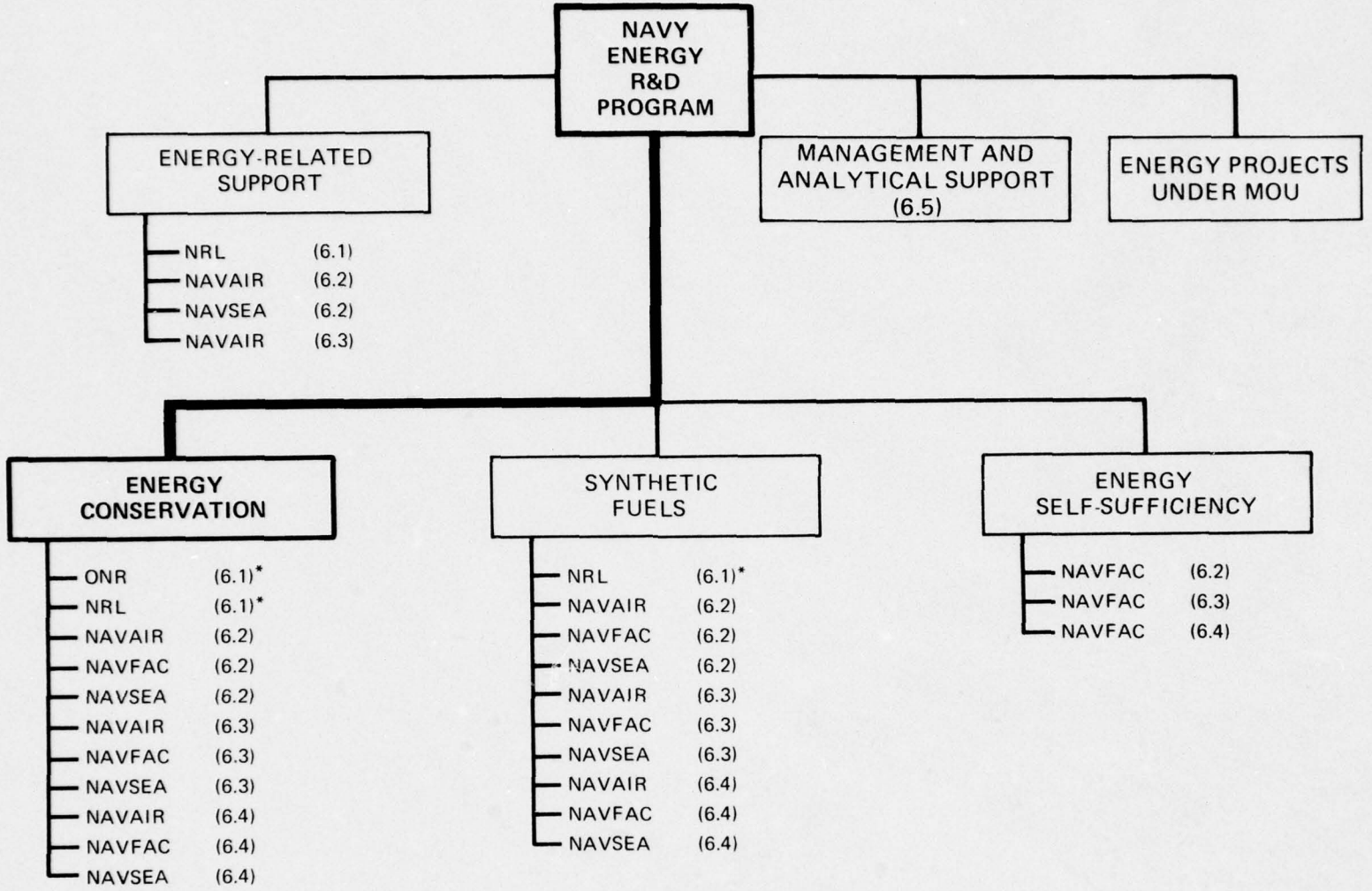


Figure 6. PROGRAM ORGANIZATION GUIDE

ENERGY CONSERVATION



*ENERGY SUPPORT ADMINISTERED BY ONR

4.2 ENERGY R&D PROJECTS BY RDT&E CATEGORY

4.2.1 Energy Conservation

In the near-term, the only means of reducing the cost and increasing the availability of energy sources is conservation. Therefore, conservation measures have been and will continue to be a primary interest of the Navy Energy and Natural Resources R&D Office.

Rigid goals for energy conservation are not possible. Energy may always be saved, for example, by a cessation of operations. If the fleet is anchored and aircraft are grounded, however, a substantial part of their effectiveness, which has been purchased and maintained at great cost, may be lost. Therefore, specific efforts must be made to reduce energy consumption without compromising the readiness and overall cost-effectiveness of Navy forces.

The primary emphasis of Navy energy conservation R&D is in:

- Developing and implementing operational practices that will eliminate losses now incurred without losing effectiveness.
- Developing new propulsion and auxiliary machinery technology having higher basic efficiency expectations than the present systems.

In keeping with the policy recommendations of the DETG, the Navy Energy and Natural Resources R&D Office has concentrated on energy conservation R&D for ships and at shore installations. The Air Force is the lead Service in aircraft energy conservation, but the Navy is defining its requirements and will conduct programs addressing energy usage aspects peculiar to Navy aircraft operations. Table 2 lists all energy conservation tasks within the Navy energy R&D program.

Table 2. ENERGY CONSERVATION PROJECTS

Page	Program Element Number	Project Number	Title and Description	Performer	Contact	Telephone Number
B-12	61153N	RR 023-01-82 229-007	**Naval Vehicle Design and Construction: High-Pressure Liquid Viscosity** Evaluate a technique based on autocorrelation technology to measure the time and pressure dependencies of liquid viscosity.	ONR	D. Lauver Code 210	(202) 692-4418
B-13	61153N	RR 023-01-82 229-012	**Naval Vehicle Design and Construction: Adhesive and Fatigue Wear Particle Production Rates** Determine the rates of production of adhesive and fatigue generated wear particles in lubricated systems as a function of applied load, speed, and material.	ONR	D. Lauver Code 210	(202) 692-4418
B-14	61153N	RR 023-01-82 229-015	***High-Pressure Viscosity Measurement*** Determine the influence of molecular structure on the time-dependent viscosity and density response of liquids and other viscoelastic materials.	ONR	D. Lauver Code 210	(202) 692-4418
B-15	61153N	RR 023-01-82 229-018	**Mechanism of Heat Generation in Elasto-hydrodynamic Contacts** Determine the magnitude of the temperature rise accompanying the compression of lubricants in bearing and concentrated contacts.	ONR	D. Lauver Code 210	(202) 692-4418
B-16	61153N	RR 024-03-02 097-396	***Material Support Technology:* Wear Reduction in Sliding Systems** Discover the mechanism by which a complex metal chalcogenide (arsenic thioantimonate) provides a 300-400 percent improvement in wear resistance when compared with molybdenum disulfide.	ONR	J. Satkowski Code 473	(202) 962-4406
B-17	61153N	RR 024-03-07 097-397	**Material Support Technology: High-Pressure Liquid Properties Relevant to Lubricants and Explosives** A theoretical understanding is sought of the time-dependent changes in properties of liquids subjected to high pressure. Of concern are the nonlinear property changes during nonequilibrium conditions.	ONR	J. Satkowski Code 473	(202) 962-4406
B-18	61153N	RR 024-03-02 097-398	**Frictional Wear Mechanisms: Machinery Wear Technology** Study the effects of localized heat conductivity, temperature, and pressure on wear mechanisms between solid materials in sliding contact.	ONR	J. Satkowski Code 473	(202) 692-4406

Table 2. ENERGY CONSERVATION PROJECTS (Cont'd)

Page	Program Element Number	Project Number	Title and Description	Performer	Contact	Telephone Number
B-19	61153N	RR 024-03-02 097-399	**Self-generated Electromotive Force in Sliding Systems** Determine the interrelationships among metallurgy, chemistry, and environment that control the rate of wear in mechanical equipment.	ONR	J. Satkowski Code 473	(202) 692-4406
B-20	61153N	RR 024-03-02 097-416	**Naval Vehicle Design and Construction: Tribology Planning Study Detailing Technical Approaches Toward the Goal of Energy Conservation** Develop a research plan aimed at accelerating the development of tribology.	ONR	J. Satkowski Code 473	(202) 962-4406
B-21	61153N	RR 024-01-01 099-407	**Liquid Metal MHD Power Generation for Nuclear Ship Propulsion** Examine the behavior of turbulence in liquid metal MHD generators in strong magnetic fields.	ONR	J. Satkowski Code 473	(202) 692-4406
B-22	61153N	RR 024-03-02 097-383	**Heat Transfer Problems in Advanced Gas Turbines** Develop the capability to predict the fluid and heat transfer that affect gas turbine performance, e.g., impingement and film cooling.	ONR	J. Satkowski Code 473	(202) 692-4406
B-23	61153N	RR 024-03-02 097-395	**Advanced Topping Cycles** Perform research into thermodynamics and fluid dynamics of convective heat transfer in closed Brayton cycle gases for marine propulsion and power systems.	ONR	J. Satkowski Code 473	(202) 692-4406
B-24	61153N	RR 024-03-02 097-401	**Improved Efficiency Conventional Power Plants: Ceramics for High-Temperature Heat Exchangers** Determine suitability of ceramics for use in high-temperature heat exchangers for shipboard propulsion systems.	ONR	J. Satkowski Code 473	(202) 692-4406
B-25	61153N	RR 024-03-02 099-404	**Liquid Metal MHD Power Generation (Argonne)** Determine the suitability of two-phase MHD generators for use in propulsion systems.	ONR	J. Satkowski Code 473	(202) 692-4406
B-26	61153N	RR 024-03-02 099-412	**MHD Flow Investigation** Analyze two-phase Hartmann flows for Faraday MHD generators.	ONR	J. Satkowski Code 473	(202) 692-4406
B-30	61153N	RR 011-02-42 P05-02.101	**Research on Properties of Materials at Ultralow Temperatures for Use with Turbine Driven Superconducting Generator Motor Systems**	NRL	D. Gubser	(202) 767-2793

Table 2. ENERGY CONSERVATION PROJECTS (Cont'd)

Page	Program Element Number	Project Number	Title and Description	Performer	Contact	Telephone Number
B-31	61153N	RR 021-03-46 R 08-78.101	**Improved Efficiency, Conventional Power Plants: Diesel and Steam Surface Studies for Energy Converters** Study the surface and interface properties of low work function materials used as low-temperature electron collectors for applicability to increasing the efficiency of fossil-fueled plants.	NRL	G. Haas	(202) 767-3577
B-32	61153N	RR 022-11-41 M01-14.101	**Properties and Engineering Application of Thermostructural Materials** Develop knowledge of such alloys under such high-temperature conditions as exist in conventional power plants.	NRL	P. Shahinian	(202) 767-2117
B-34	61153N	RR 024-01-45 C05-13.101	**Fundamental Study of Electrode Reactions** Study battery electrode processes to develop more powerful and efficient military batteries.	NRL	E. Wells	(202) 767-3617
B-35	61153N	RR 024-03-41 C05-26.101	**High Temperature and Pressure Chemistry Related to Improved Thermal Energy Conversion** Improve the performance, reliability and efficiency of shipboard boilers, evaporators, etc., through chemical reduction of corrosion, scaling, and sludging.	NRL	D. Venezky	(202) 767-2127
B-37	61153N	RR 024-01-45 E01-07.101	**Transfer and Storage for Thermal Power Systems for Use with Combined Chemical Dash Power and Nuclear Cruise Power Systems** Perform experimental study of proof-of-concept energy storage unit using heat-of-fusion eutectic salt storage and heat pipe energy transport. Design 2 Mwh storage tank with internal 150 kw steam generator.	NRL	T. Chubb	(202) 767-3580
B-42	62765N	ZF57-571-004	**Aircraft Fuel Conservation Analysis Program** Study and analyze USN/USMC aircraft types and classes, fuel usage and potential fuel savings solutions by design changes and modifications and/or mission operations.	NAVAIR/ NADC	H. Hollenberg W. Miller	(202) 692-7448 (215) 441-2497
B-46	62765N		**Construction Methods and Materials** Determine thermal, structural, safety, and related characteristics of new construction methods and materials.	CEL	E. Vinieratos	(805) 982-5973
B-48	62765N		**Heating and Cooling Loads Computer Simulation** Develop Loads and Systems Simulation (LASS) model to provide an accurate method of evaluating building heating and cooling loads.	CEL	E. Vinieratos	(805) 982-5973

Table 2. ENERGY CONSERVATION PROJECTS (Cont'd)

Page	Program Element Number	Project Number	Title and Description	Performer	Contact	Telephone Number
B-49	62765N		**Measurement of Building Energy Losses** Evaluate and test instrumentation and techniques to locate and measure energy losses from buildings.	CEL	J. King	(805) 982-5973
B-50	62765N		**Concrete Sandwich Construction Materials Tests** Examine characteristics and potential benefits of insulated expansive concrete sandwich construction.	CEL	J. Keeton	(805) 982-5793
B-51	62765N		**Low-Energy Structures** Develop and demonstrate low-energy structures concepts for new construction which will satisfy need for reduced energy consumption.	NWC	D. Wirtzl G. Smith	(714) 939-7273
B-52	62765N		**Seawater Cooling Survey** Perform bathythermographic measurements at four candidate Navy sites.	CEL	J. Ciani	(805) 982-4642
B-53	62765N		**Navy Cogeneration** Determine feasibility of and survey applicable Navy sites for cogeneration facilities.	CEL	E. Cooper	(805) 982-5975
B-54	62765N		**Low-Temperature Heat-Recovery Power Systems** Assess the technical and economic feasibility of organic Rankine cycle bottoming systems for improved fuel economy for Navy applications.	CEL	H. Gaberson	(805) 982-5975
B-55	62765N		**Measurement of Energy Losses in Pipelines** Evaluate and test instrumentation and techniques for detecting leaks in various types of pipelines.	CEL	J. King	(805) 982-5973
B-57	62765N		**Electrical Conservation Technology Base** Investigate electrical control, distribution, and power transmission equipment for its conservation potential and applicability for use with alternative energy sources. Develop a lighting application criteria handbook and investigate lighting advances for impact on energy conservation.	CEL	W. Pierpoint	(805) 982-5778
B-58	62765N		**Detection and Measurement of Energy Losses in Electrical Distribution Systems** Evaluate instrumentation and procedures for measuring losses in electrical distribution systems.	CEL	J. King	(805) 982-5973

Table 2. ENERGY CONSERVATION PROJECTS (Cont'd)

Page	Program Element Number	Project Number	Title and Description	Performer	Contact	Telephone Number
B-59	62765N		**Analysis of Installed Monitoring and Control Systems** Examine existing monitoring and control systems for parameters affecting future procurement and system developme nt.	CEL	D. Johnson	(805) 982-5795
B-61	62765N		**Energy Conservation Handbook** Prepare an energy conservation handbook for Navy construction applications.	CEL	F. Herrman	(805) 982-5562
B-62	62765N		**Energy Optimization Handbook for Navy Base Planning** Prepare handbook for predetermining optimum mixtures of environmentally driven power systems and energy conservation systems for planning Naval applications.	CEL	C. Parker	(805) 982-4326
B-63	62765N		**Energy Systems Application Survey** Determine the potential applications of energy conservation devices by conducting a base-by-base market survey.	CEL	C. Parker	(805) 982-4326
B-64	62765N		**Application Engineering Studies** Provide RDT&E assistance to coordinate technology flow between national and Navy energy programs.	CEL	F. Herrmann	(805) 982-5562
B-66	62765N		**Study of Capital Expense Premium to be Allowed for Energy-Saving Physical Plant Investments**	CEL/NWC	C. Parker E. Kappelman	(805) 982-4326 (714) 939-7334
B-67	62765N		**Data Compilation for Energy Consumption and Facility Operational Statistics** Compile on-site statistics and data related to energy demand and consumption at Naval installations. Determine the site characteristics at Sewells Point Navy Base to characterize energy usage.	CEL	R. Bergman	(805) 982-5377
B-73	62765N		**Energy Conservation Aboard Ship** Identify the potential for reduced fuel consumption in future ships through alternative propulsion and auxiliary systems.	DTNSRDC	C. Krolick	(301) 267-2674
B-80	63210N	W05XX	**Long-Endurance Aircraft Engine** Develop a very high efficiency aircraft engine for use in Navy long-endurance patrol aircraft.	NAVAIR	E. Lichtman	(202) 692-2518
B-84	63724N	Z0829	**Navy Cogeneration** Perform in-depth analysis for cogeneration plants at Navy sites and develop a planning guide for public works usage.	CEL	E. Cooper	(805) 982-5975

Table 2. ENERGY CONSERVATION PROJECTS (Cont'd)

Page	Program Element Number	Project Number	Title and Description	Performer	Contact	Telephone Number
B-85	63724N	Z0829	**Electrical System Experiments** Verify and apply theory developed from electrical conservation technology base project. Develop and test automatic lighting control systems for quality illumination and electrical conservation. Develop a lighting maintenance scheduling computer program.	CEL	W. Pierpoint	(805) 982-5778
B-87	63724N	Z0829	**Engineering Guidance for Monitoring and Control Systems** Develop and demonstrate a microprocessor time clock and determine capabilities of a modularized approach to monitoring and control system expansion.	CEL	D. Johnson	(805) 982-5795
B-89	63724N	Z0829	***Energy Conservation Handbook*** Adapt the Air Force/National Bureau of Standards Retrofit Energy Conservation Handbook for Navy applications.	CEL	F. Herrman	(805) 982-5562
B-90	63724N	Z0829	**Recommendations on Efficiency Improvement Devices for Conventional Boilers** Develop and evaluate new boiler hardware, procedures, and concepts for efficiency improvement.	CEL	T. Fu	(805) 982-5975
B-91	63724N	Z0829	**Instrumentation Packages for Field Surveys** Determine suitable instrumentation and formulate users guide for conducting field surveys of energy losses.	CEL	J. King	(805) 982-5973
B-92	63724N	Z0829	**Navy Industrial Use Surveys** Perform surveys at Navy shipyards and aircraft repair facilities to determine industrial energy losses.	CEL	–	–
B-98	63724N	Z0829	***Hull Maintenance*** Develop improved underwater hull cleaning techniques, biofouling protection systems, and hull coatings.	DTNSRDC	C. Krolick	(301) 267-2674
B-102	63724N	Z0829	**Advanced Ship Components** Provide model tests and hardware demonstration of machinery systems and components for the present and future fleets.	DTNSRDC	C. Krolick	(301) 267-2674
B-114	64710N	Z0371	**Polyurethane Foam Roofing Systems** Determine optimum polyurethane roofing systems and maintenance procedures for new applications on Navy facilities.	CEL	R. Alumbaugh	–

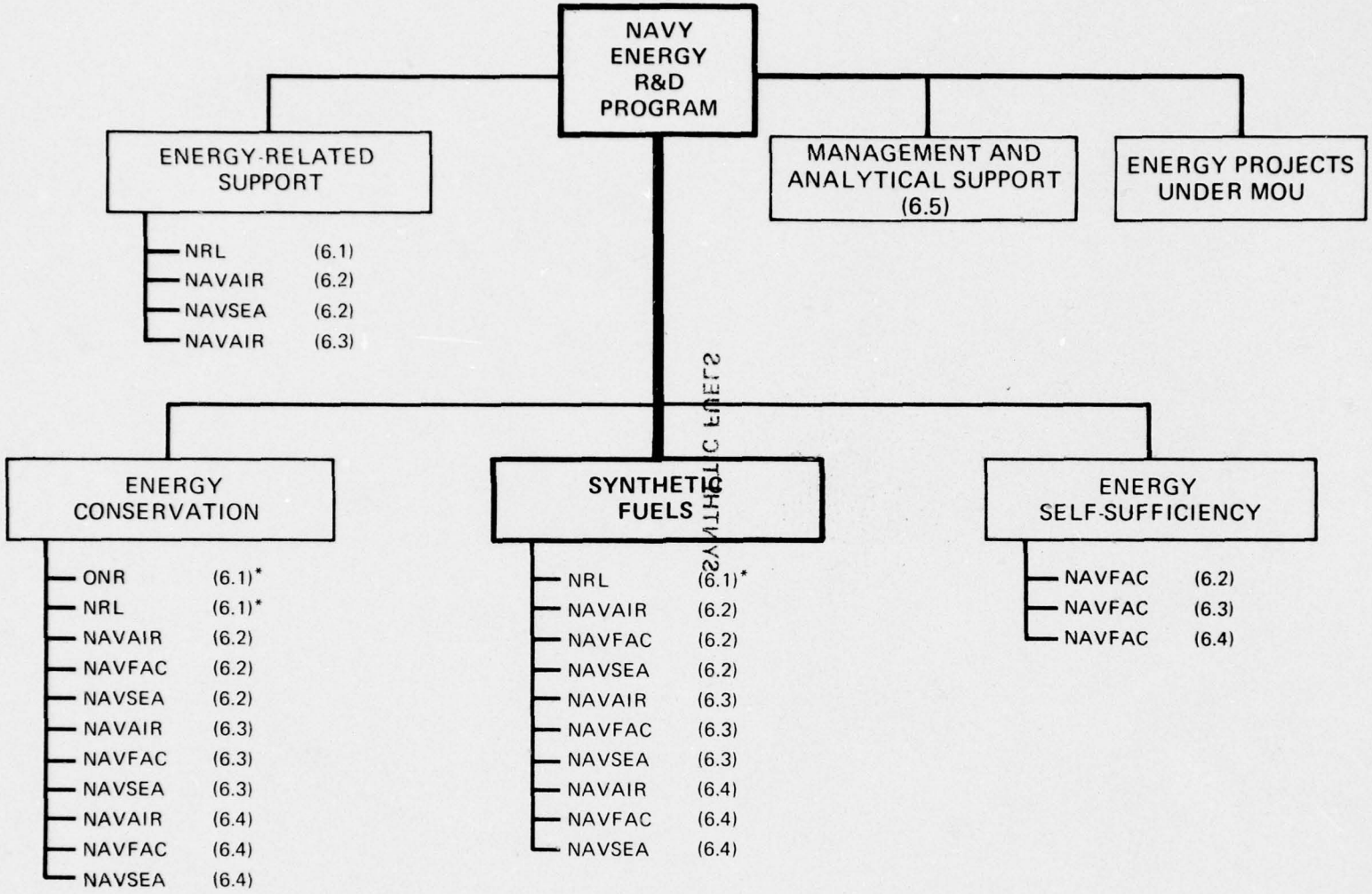
Table 2. ENERGY CONSERVATION PROJECTS (Cont'd)

Page	Program Element Number	Project Number	Title and Description	Performer	Contact	Telephone Number
B-115	64710N	Z0371	**Seawater Cooling for Buildings** Prepare final design, fabrication, instrumentation, and installation of a demonstration seawater cooling system at a selected Navy site.	CEL	J. Ciani	(805) 982-4642
B-116	64710N	Z0371	**Navy Cogeneration** Develop and demonstrate a prototype cogeneration plant at a selected Navy site.	CEL	E. Cooper	(805) 982-5975
B-117	64710N	Z0371	**Economic and Operational Potential for High-Technology Modifications of Installed Energy Monitoring and Control Systems**	CEL	R. Stabb	(805) 982-5778
B-118	64710N	Z0371	**Recommendations on Efficiency Improvement Devices for Conventional Boilers** Demonstrate new boiler hardware, procedures and concepts for efficiency improvement.	CEL	T. Fu	(805) 982-5975
B-119	64710N	Z0371	**Air Conditioning Tune-up Program** Demonstrate a test program to detect, locate and correct problems in Navy air conditioning systems.	CEL	–	–
B-120	64710N	Z0371	**Low-Energy Structures** Develop and demonstrate low energy structure concepts for retrofit construction on existing buildings which will satisfy the need for reduced energy consumption.	NWC	D. Wirtzl G. Smith	(714) 939-7273
B-121	64710N	Z0371	**Industrial Surveys** Determine energy end-use of an aircraft/avionics government-owned contractor-operated facility.	CEL	–	–
B-127	64710N	Z0371	**Hull Maintenance** Perform at-sea testing of hull cleaning and hull coatings development efforts.	DTNSRDC	C. Krolick	(301) 267-2674
B-131	64710N	Z0371	**Machinery Optimization** Identify energy-intensive machinery systems in the present fleet and optimize through equipment and procedural modifications.	DTNSRDC	C. Krolick	(301) 267-2674
B-134	64710N	Z0371	**Feedback-Limited Combustion Control System** Develop a feeback controlled system to regulate boiler combustion air.	DTNSRDC	C. Krolick	(301) 267-2674

Table 2. ENERGY CONSERVATION PROJECTS (Cont'd)

Page	Program Element Number	Project Number	Title and Description	Performer	Contact	Telephone Number
B-135	64710N	Z0371	**2000 kw Quiet Diesel Generator** Procure, test and evaluate a quiet diesel generator set suitable for installation on ASW combatants.	DTNSRDC	C. Krolick	(301) 267-2674
B-136	64710N	Z0371	**Water Resource Management** Formulate procedures and techniques to improve efficiency of fresh-water production and utilization aboard ship.	DTNSRDC	C. Krolick	(301) 267-2674
B-138	64710N	Z0371	**Shipboard Machinery Performance Monitoring**	DTNSRDC	C. Krolick	(301) 267-2674
B-142	65861N	Z0362	**Energy Usage Statistics for Sewells Point** Determine the site characteristics of Sewells Point Navy Base to characterize energy usage.	CEL	R. Bergma n	(805) 982-5377
B-143	65861N	Z0362	**Review of Guidance Governing Centralized Steam and Electric Power Generation by Naval Installations**	CEL	D. Williams	(805) 982-4207

SYNTHETIC FUELS



*ENERGY SUPPORT ADMINISTERED BY ONR

4.2.2 Synthetic Fuels

Most of the recent studies to determine world petroleum resources have concluded that planning should be based on the expectation that petroleum resources will become exhausted within this century. Since fuels produced from petroleum are, at present, vital to Navy operations, the expectation that petroleum supplies will be depleted in the near term is an important factor in the Navy's energy R&D planning.

Continued use of hydrocarbon fuels by the Navy over the next 50 years is a certainty; therefore, the primary concern is continued availability, even though the price will be high. The United States has extremely large resources of oil shale, tar sands, and coal, from which hydrocarbon fuels can be made. The supply of these U.S. resources dwarfs the world's supply of petroleum and will not be depleted for a century or more. Even after fossil sources are depleted, hydrocarbon fuels could be produced by direct synthesis from inorganic materials.

Extensive national R&D programs are currently directed toward the development of these resources. A major goal of the national synthetic fuel program is commercialization. Improved oil shale and coal processes are now at the pilot-plant stage. The construction of commercial-scale processing plants in the United States is being delayed by capital requirements, legal restrictions, environmental constraints, and an inadequate national energy policy. However, commercial-scale oil shale plants could begin operation in the 1980s. The coal situation is more complicated. Coal requires considerable hydrotreating to produce middle-distillate fuels, but liquid feedstocks from coal are an excellent source of gasoline, boiler utility fuels, and petrochemical feedstock.

The Navy's plan is to ensure the continued availability of the preferred hydrocarbon fuels, with a primary emphasis on fuels that are now becoming available from non-petroleum fossil sources. Extensive national R&D programs are currently directed toward the development of these resources. The Navy's supporting approach is to:

- Ensure that the Navy is an informed customer for the resulting products.
- Ensure that the products that result from the national synthetic fuel program will be suitable for Navy needs.

Table 3 lists all the synthetic fuels projects within the Navy energy R&D program.

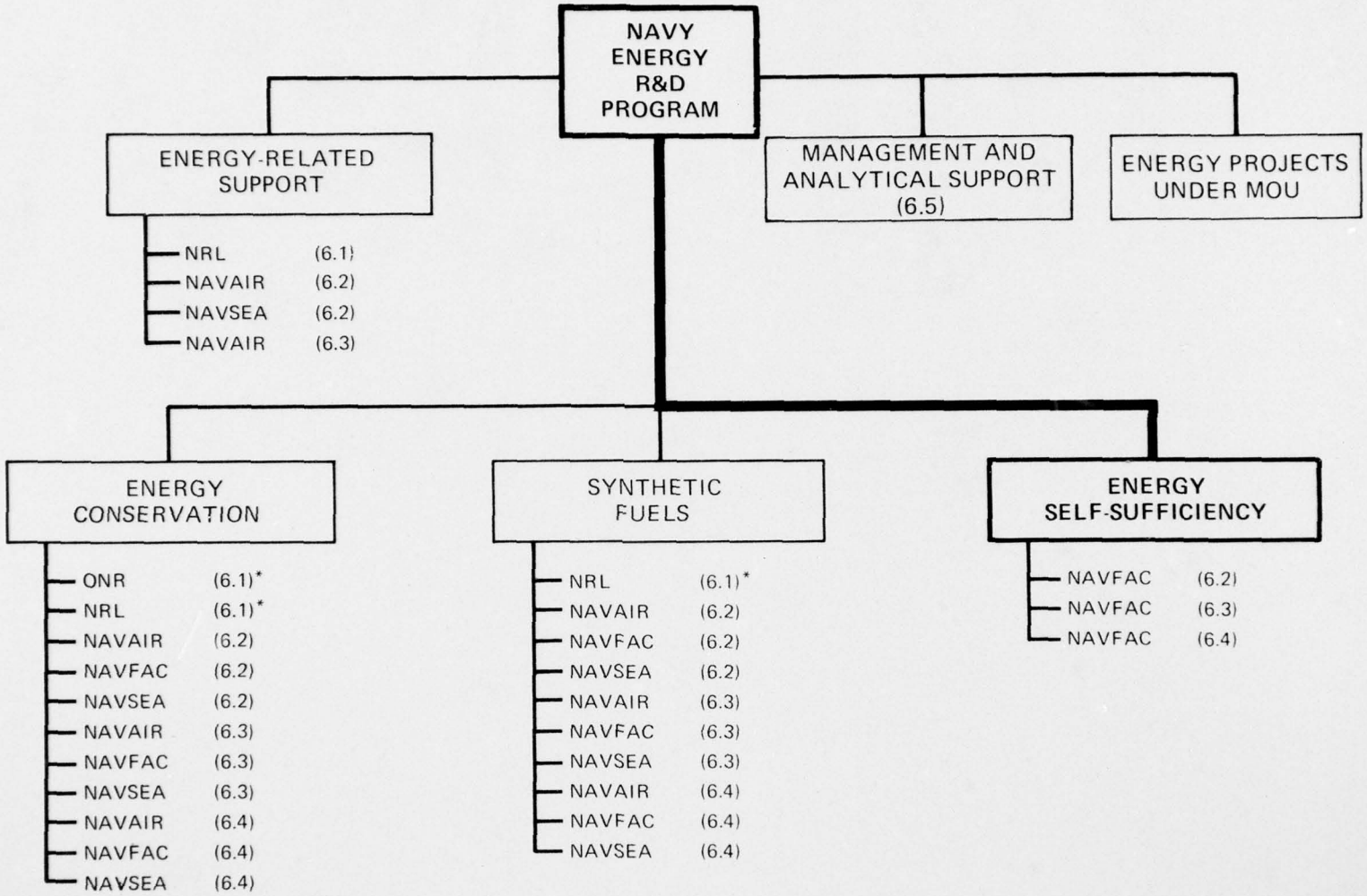
Table 3. SYNTHETIC FUEL PROJECTS

Page	Program Element Number	Project Number	Title and Description	Performer	Contact	Telephone Number
B-166	61153N-24	RR 024-02-41	**Synthetic Fuel Process** Develop processes to produce moderate molecular weight hydrocarbons by low-temperature oxidation of coal with air using catalytic agents, if necessary. Determine the chemical mechanisms involved in the oxidation and decomposition reactions.	NRL	R. Hazlett	(202) 767-3559
B-170	62765N	ZF57-571-004	**Energy Conversion/Synthetic Fuels** Evaluate physical and chemical characteristics of nonspecification and synthetic JP-5, including reactivity, storage stability, and conformity to specifications. Investigate compatibility, performance, safety hazards, and handling requirements.	NAPTC/ NRL	C. Nowack	(609) 882-1416
B-176	62765N		**Waste/Fresh Oil Blends** Verify the ability to burn high concentrations and waste oil blended with fresh oil in Navy boilers.	CEL	T. Fu	(805) 982-5975
B-190	62765N	ZF57-571-005	**New Energy Sources/New Fuel Sources** Evaluate synthetic fuels for Navy weapon systems by laboratory analyses of specifications, physical and chemical characterization, and upgrading investigations. Perform assay analyses of synthetic crude for DFM and alternative product yields. Investigate other synthetic fuel sources. Conduct fuel flexibility studies of non-MILSPEC petroleum products.	DTNSRDC	C. Krolick	(301) 267-2674
B-186	63724N	Z0838	**Small-Scale Aircraft Energy Testing with Synthetic Fuels** Determine actual engine performance and emissions characteristics using synthetic JP-5 in tests with T63 and TF-34 engines.	NAPTC	C. Nowack	(609) 882-1416
B-190	63724N	Z0838	**Coal Utilization Systems—Central Coal Gasification Plant** Develop preliminary design and perform feasibility study for fuel gas plant for Navy bases. Determine the expected price of synthetic pipeline quality gas for use in Navy fuel cost projections.	CEL	D. Williams	(805) 982-5976
B-194	63724N	Z0839	**Light Refined Liquid Fuels for Ships** Perform computer-sponsored studies of synthetic fuel impact in terms of system compatibility, logistics and handling problems, fire and safety hazards, and toxicological effects. Consider broader synthetic fuel specifications to allow greater fuel flexibility.	DTNSRDC	C. Krolick	(301) 267-2674

Table 3. SYNTHETIC FUEL PROJECTS (Cont'd)

Page	Program Element Number	Project Number	Title and Description	Performer	Contact	Telephone Number
B-200	64710N	Z0347	**Sea-Going Flight Tests of Synthetic Fuels in Navy Aircraft** Perform final qualification of synthetic JP-5 fuel verifying compliance with maximum performance requirements under conditions of actual carrier-dependent aircraft operations. Develop handling and safety expertise.	NAPTC	C. Nowack	(609) 882-1416
B-203	64710N	Z0347	**Endurance Testing of Synthetic Fuels in Shoreside Systems** Investigate synthetic fuel performance under extended, full-scale operational conditions. Determine requirements for Navywide implementation and operation.	CEL	T. Fu	(805) 982-5975
B-207	64710N	Z0347	**Sea Trials of Synthetic Fuels for Navy Ships** Perform final sea-trial qualifications of synthetic DFM for fleetwide use including identification of handling and personnel training requirements and evaluation of long-term effects on the operational environment.	DTNSRDC	C. Krolick	(301) 267-2674

ENERGY SELF-SUFFICIENCY



*ENERGY SUPPORT ADMINISTERED BY ONR

4.2.3 Energy Self-sufficiency

The technical objective of the energy self-sufficiency strategy is to demonstrate technical feasibility and collect cost and performance data on hardware and systems that will reduce dependence on conventional energy supplies. The Navy's strategy to develop and apply these technologies will provide several widespread benefits:

- Decreased dependence on petroleum supplies, especially for remote locations, which are in more danger of supply line interruption and which involve higher transportation costs.
- Mechanisms to keep the Navy well informed on national efforts to develop energy technologies, e.g., solar conversion systems, that soon may be applied in both civilian and military systems.
- Application of systems and development of resources in a manner that may have fewer adverse environmental effects than conventional sources and systems.
- Contribution of user experience and operational data to the civilian sector.

The Navy Energy Program Office, located at CEL, Port Hueneme, California, in executing the tasks in the energy self-sufficiency strategy, will conduct investigations (both through contracts and at CEL), then transfer the technology to NAVFAC and other field activities. NWC, China Lake, will provide extensive support in geothermal, wind, and solar research activities. Close coordination will be maintained with the Army, Air Force, and civilian sector, particularly ERDA, to prevent duplication of effort and to take every advantage of the advances made by other groups. Systems made available through ERDA and industry will be used for application studies whenever feasible. Table 4 lists the energy self-sufficiency projects within the Navy energy R&D program.

Table 4. ENERGY SELF-SUFFICIENCY PROJECTS

Page	Program Element Number	Project Number	Title and Description	Performer	Contact	Telephone Number
B-222	62765N		**Solar Projects for the Advanced Energy Utilization Test Bed (AEUTB)** Test solar collector and storage methods integrated with HVAC systems.	CEL	H. Zwibel	(805) 982-5119
B-223	62765N		**Solar Heating and Cooling Design Guide** Provide technical guidance for site selection and evaluation of solar systems.	CEL	H. Zwibel	(805) 982-5119
B-224	62765N		**Preliminary Assessment of Photovoltaic Equipment for Advanced Bases**	CEL	H. Zwibel	(805) 982-5119
B-225	62765N		**Feasibility of Solar Desalination Applications at Navy Sites**	CEL	H. Zwibel	(805) 982-5119
B-226	62765N		**Advanced HVAC System Testing—Solar Augmented Heat Pump Studies**	CEL	A. McClaine	(805) 982-4207
B-227	62765N		**Energy Storage Techniques** Define Navy requirements for storage systems integrated with use of local energy sources.	CEL	H. Zwibel	(805) 982-5119
B-228	62765N		**Advanced Power Cycles for Advanced Bases** Evaluate feasibility of alternate fuels for advanced bases.	CEL	E. Cooper	(805) 982-4207
B-229	62765N		**Alternative HVAC Systems Studies** Economic evaluations and comparisons of solar air conditioning systems.	CEL	R. Chapler	(805) 982-5119
B-230	62765N		**Evaluation of 5- to 10-kw Capacity Wind Generators to Supply Power for Buildings**	CEL	D. Pal	(805) 982-4207
B-232	62765N		**Feasibility of Small-Scale Vertical-Axis Wind Machines** Determine feasibility of small-scale vertical-axis wind machines for conversion of wind energy for space heating.	CEL	D. Pal	(805) 982-4207
B-233	62765N		**Handbook for Application of Wind Power Generators at Naval Facilities**	CEL	D. Pal	(805) 982-4207
B-234	62765N		**Site Selection for Installation and Testing of 100- to 1,500-kw Wind Generators**	CEL	D. Pal	(805) 982-42007
B-235	62761N		**Geothermal Utilization Technology for Remote Sites** Identify equipment suitable for use with geothermal power at Naval bases.	NWC	R. Fulmer	(714) 939-7350
B-236	62761N		**Navy Geothermal Site Assessment** Survey Navy sites to select and prioritize for geothermal development.	NWC	C. Austin	(714) 939-2700

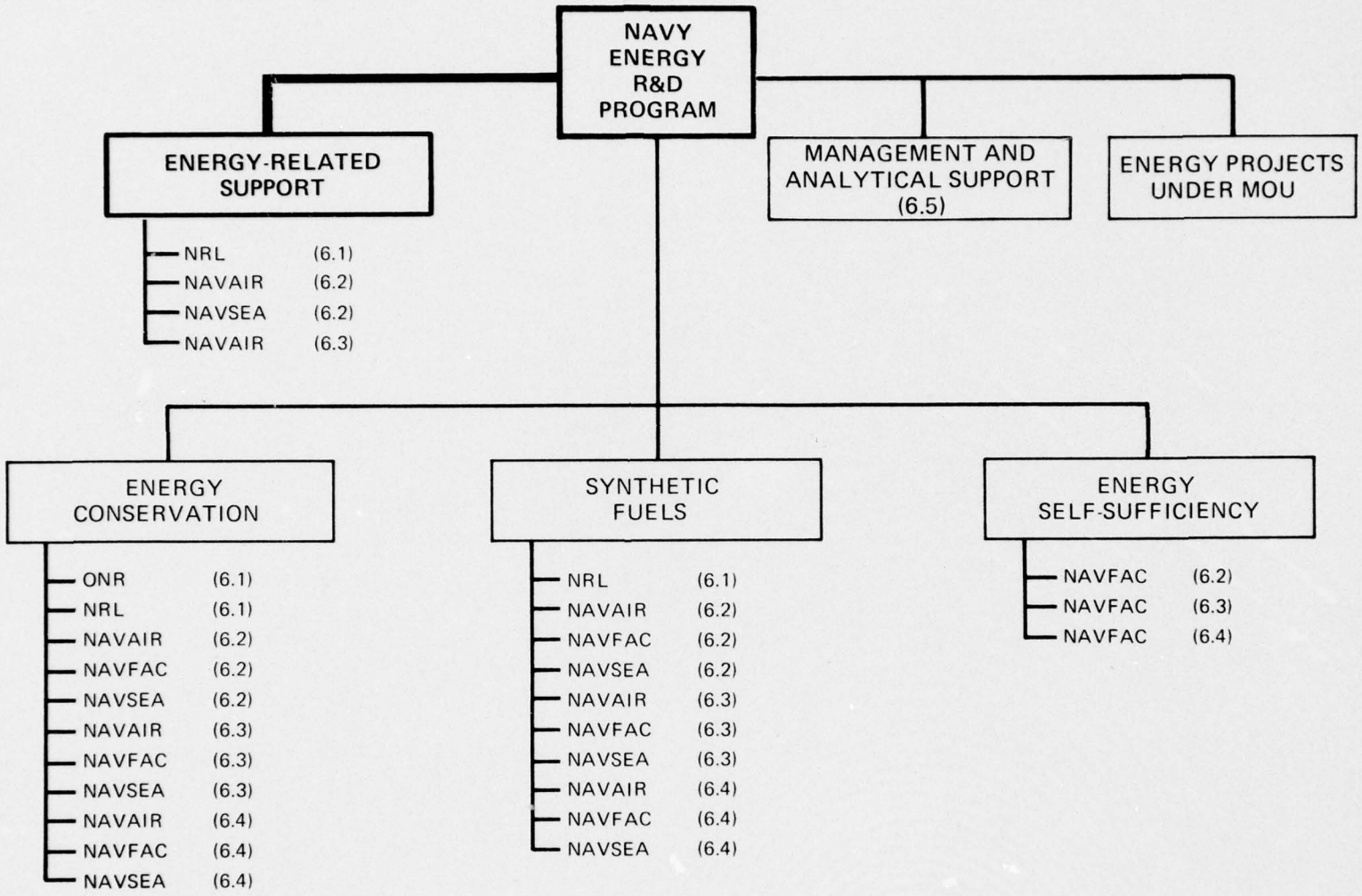
Table 4. ENERGY SELF-SUFFICIENCY PROJECTS (Cont'd)

Page	Program Element Number	Project Number	Title and Description	Performer	Contact	Telephone Number
B-237	62761N		**Adak Geothermal Resource Development** Assess potential of Adak site for geothermal development.	NWC	C. Austin	(714) 939-2700
B-238	62761N		**Coso Geothermal Resource Development** Evaluate results of USGS and ERDA geological/geophysical studies of Coso site.	NWC	C. Austin	(714) 939-2700
B-239	62761N		**Geothermal Legal/Institutional Study** Identify legal/institutional problems and provide guidelines to Navy for management of geothermal resources.	NWC	R. Fulmer	(714) 939-7350
B-240	62761N		**Geothermal Impact on Navy Missions** Identify Navy missions and characterize geothermal operations to determine effect on basic Navy missions.	NWC	C. Austin	(714) 939-2700
B-241	62761N		**Geothermal Corrosion Studies** Explore causes and nature of corrosion at specific Navy sites.	NWC	C. Austin	(714) 939-2700
B-242	62764N		**Preliminary Analysis of Combined Liquid and Solid Waste Processes**	CEL	P. Stone	(805) 982-4207
B-244	62765N		**Small-Scale Densified RDF Process Equipment** Determine parameters desirable in a densified RDF for direct thermal conversion.	CEL	M. Boogay	(714) 939-4173
B-245	62765N		**Conversion of Solid Waste to Gasoline** Develop and demonstrate technology to produce gasoline from trash and to quantify yields and energy efficiencies.	NWC	C. Benham	(714) 939-7263
B-246	62765N		**Site Characteristics** Assemble energy-related environmental derived data for Navy bases.	CEL	R. Bergman	(805) 982-4116
B-248	62765N		**Evaluation of New Coal Technologies** Recommend new coal technologies for application at Navy bases.	CEL	D. Williams	(805) 982-5974
B-252	63724N	Z0840	**Applicability of a Photovoltaic System**	CEL	H. Zwibel	(805) 982-5119
B-253	63724N	Z0840	**Preliminary Design of a Solar Desalination System**	CEL	H. Zwibel	(805) 982-5119
B-254	63724N	Z0840	**Advanced HVAC System Testing–Solar Augmented Heat Pump Demonstration**	CEL	A. McClaine	(805) 982-4207

Table 4. ENERGY SELF-SUFFICIENCY PROJECTS (Cont'd)

Page	Program Element Number	Project Number	Title and Description	Performer	Contact	Telephone Number
B-255	63724N	Z0840	**Demonstration of Energy Storage Techniques**	CEL	A. McClaine	(805) 982-4207
B-256	63724N	Z0840	**Demonstration of Solar Air-Turbine Generator**	CEL	E. Cooper	(805) 982-4207
B-257	63724N	Z0840	**Alternate HVAC Systems Testing**	CEL	R. Chapler	(805) 982-5119
B-258	63724N	Z0840	**Testing of 5- to 10-kw Capacity Wind Generators to Supply Power for Buildings** Test 10-kw wind generators in 4-year evaluation project at Navy sites.	CEL	D. Pal	(805) 982-4207
B-260	63724N	Z0840	**Application of ERDA-Developed 100-kw Wind Generators** Collect cost and performance data for a 100-kw unit for 3 years.	CEL	D. Pal	(805) 982-4207
B-261	63724N	Z0840	**Adak Geothermal Resource Development** Drill exploratory well to verify and characterize resource.	NWC	C. Austin	(805) 939-2700
B-262	63724N	Z0840	**Investigation of Geothermal Sites** Conduct detailed evaluation of geothermal potential at Navy sites.	NWC	C. Austin	(805) 939-2700
B-263	63724N	Z0840	**Demonstration of Packaged Heat-Recovery Incinerator** Study various refuse-deriv ed fuel systems and demonstrate compatibility with Navy shore systems.	CEL	P. Stone	(805) 982-4207
B-264	63724N	Z0840	**Design and Demonstration of Combined Liquid and Solid Waste** Demonstrate a prototype system for recycling of liquid and solid wastes to energy.	CEL	P. Stone	(805) 982-4207
B-265	63724N	Z0840	**Small-Scale Densified RDF Process Equipment Testing** Obtain data on operating RDF system.	CEL	M. Boogay	(714) 939-4173
B-266	63724N	Z0840	**Development of a Navy Energy Self-Sufficiency Plan/Demonstration** Provide guidelines to Navy installations for selection, identification, and integration of alternative energy sources.	NWC	C. Austin	(805) 939-2700
B-270	64710N	Z0350	**Demonstration of Photovoltaic System** Determine applicability at an advanced base.	CEL	H. Zwibel	(805) 982-5119
B-271	64710N	Z0350	**Full-Scale Solar Desalination System**	CEL	H. Zwibel	(805) 982-5119
B-272	64710N	Z0350	**Application of ERDA-Developed 1,500-kw Wind Generators**	CEL	D. Pal	(805) 982-4207

ENERGY-RELATED SUPPORT


NAVY ENERGY R&D PROGRAM
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MANAGEMENT AND ANALYTICAL SUPPORT (6.5)
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4.2.4 Energy-Related Support

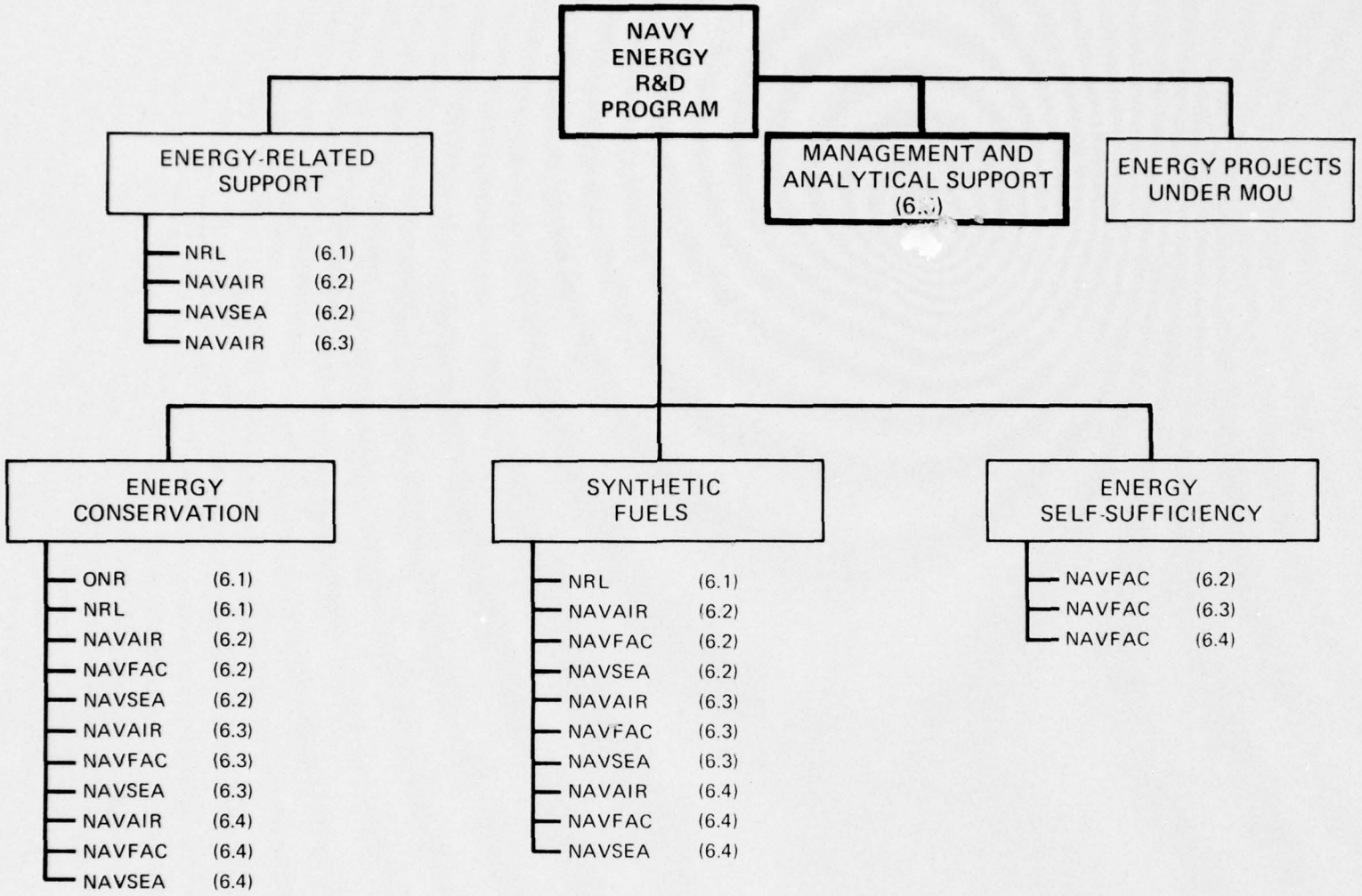
This section contains a synopsis of Navy projects related to energy that are not managed by the Navy Energy and Natural Resources R&D Office. NRL conducts several efforts in Category 6.1 that provide technical capability and physical facilities in support of fusion technology. The fusion power programs are coordinated with ERDA. NAVAIR conducts several efforts in Categories 6.2 and 6.3 that are related to improved aircraft propulsion systems. None of these efforts are directly related to any particular energy strategy. Table 5 lists all of these energy-related support projects that do not fall within one of the three primary strategies of the Navy energy R&D program.

Table 5. ENERGY-RELATED SUPPORT PROJECTS

Page	Program Element Number	Project Number	Title and Description	Performer	Contact	Telephone Number
B-283	61153N-11	RR 011-09-41	**Pulsed Power** Develop techniques to provide power for pulsed radiating weapons and X-ray generators from transformers that create impulsive magnetic fields resulting from the collapse of conducting cylinders under external magnetic pressure.	NRL	P. Turchi	(202) 767-2724
B-284	61153N-11	RR 011-09-41	**Numerical Simulation and Design of Pulsed Power Experiments** Conduct a theoretical study of the dynamics, energy requirements, and stability of magnetic fields generated by imploding conducting cylinders for pulsed power and plasma compression experiments.	NRL	P. Turchi	(202) 767-2724
B-285	61151N	RR 011-09-41	**Cusp Plasma Preheating Experiment** Create and contain warm plasma in a magnetic cusp geometry by a two-stage process utilizing neodymium-glass and carbon dioxide lasers.	NRL	P. Turchi	(202) 767-2724
B-286	61153N-22	RR 022-09-41	**Research on Mechanism of Neutron Radiation Damage to Structural Materials** Develop improved materials for high-temperature nuclear systems through study of radiation damage from neutron bombardment. Use transmission electron microscopy to evaluate effects of temperature, fluence, flux, microstructure, and solute elements on void formation and helium embrittlement in various alloys.	NRL	F. Schmitt	(202) 767-2565
B-291	63210N	W0590	**Joint Technology Demonstrator Engine** Impleme nt the joint Navy/Air Force turbine engine development plant combining the component technology developed under propulsion component technology with that developed under the USAF aircraft turbine engine gas generator program.	NAVAIR/ NAPTC	E. Lichtman	(202) 692-2518
B-292	63210N	W0580	***Propulsion Component Technology*** Develop propulsion component technology, especially high-temperature, high-workload turbines and improved heat-releasing combustors in support of the construction of a joint technology demonstrator engine.	NAVAIR/ NADC*	E. Lichtman	(202) 692-2518
B-293	63210N	W0581	**Self-Sufficient Starting System** Develop self-sufficient, single and multiple aircraft engine starting units to reduce the requirement for ground support and to provide emergency power for aircraft maneuvers and in-flight starting.	NAVAIR/ NAPTC	E. Lichtman	(202) 692-2518

*Naval Air Development Center.

MANAGEMENT AND ANALYTICAL SUPPORT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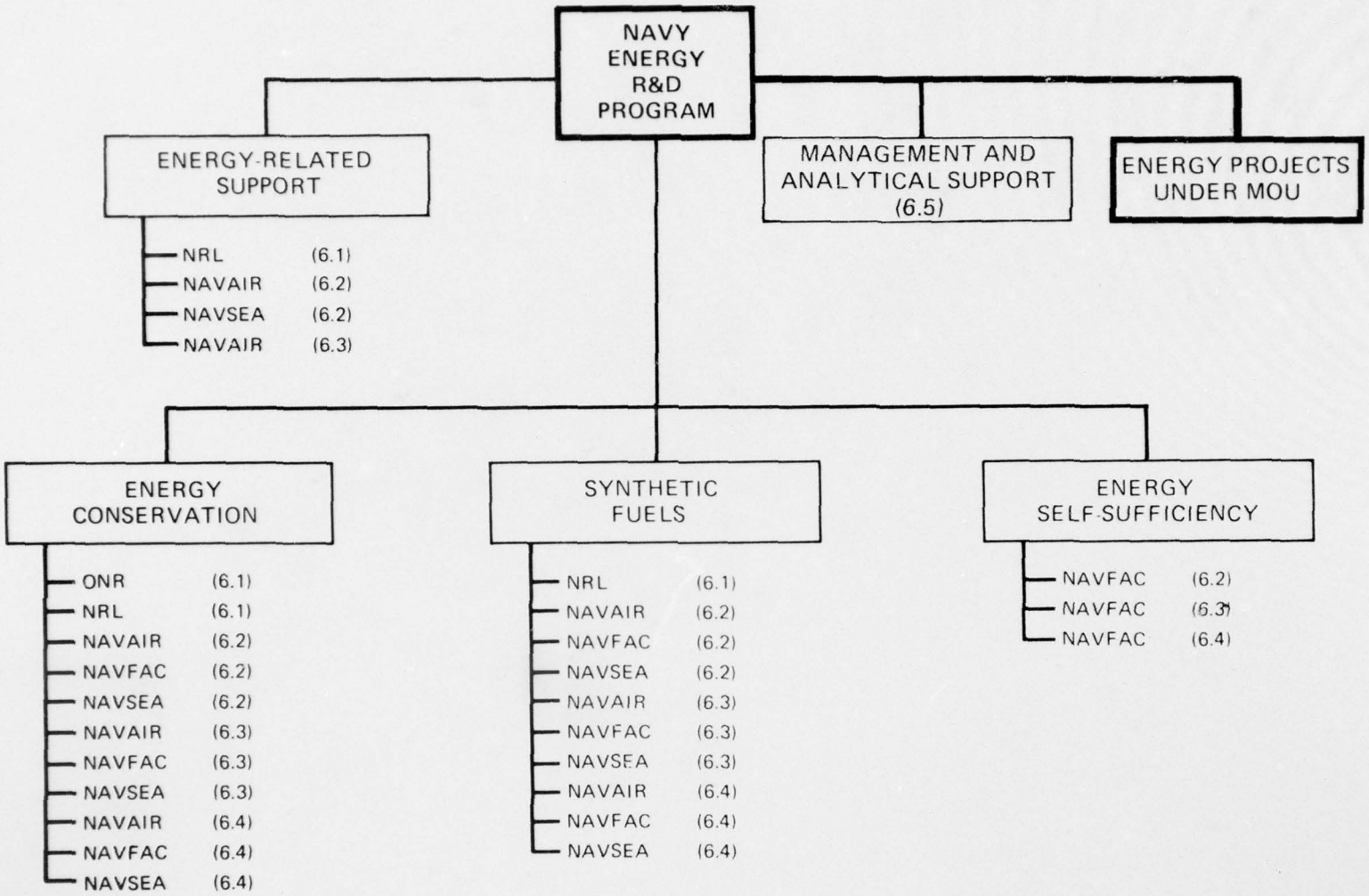
4.2.5 Energy Management and Analytical Support

This work category encompasses Navy in-house management of the energy R&D program and includes technical analyses and studies necessary for this management. Analyses and studies are assigned by the Director, Navy Energy and Natural Resources R&D Office to Navy laboratories and contractors. Table 6 lists the management and analytical tasks within the Navy energy R&D program.

Table 6. ENERGY MANAGEMENT AND ANALYTICAL SUPPORT PROJECTS

Page	Program Element Number	Project Number	Title and Description	Performer	Contact	Telephone Number
B-298	65861	Z0362	**Navy Energy Usage Profile Study** Maintain, update, and report Navy energy usage and projections of future usage.	DTNSRDC	C. Krolick	(301) 267-2674
B-299	65861	Z0362	**Navy Critical Materials Study** Analyze the current and projected Navy reliance on potentially critical materials.	DTNSRDC	C. Krolick	(301) 267-2674
B-301	65861	Z0362	**Technical Assistance to Navy Energy R&D Office** Provide a weekly situation report (SITREP), an energy fact book, an updated Energy R&D Program Plan, a report of energy R&D progress, and technical reviews, evaluations, and reports as required.	MAT-08T3	B. Sobers	(202) 692-1444
B-303	65861	Z0362	**Energy Usage Statistics for Sewells Point** Determine site characteristics of Sewells Point Navy Base to characterize energy usage.	CEL	R. Bergman	(805) 982-5377
B-304	65861	Z0362	**Review of Guidance Governing Centralized Steam and Electric Power Generation by Naval Installations**	CEL	D. Williams	(805) 982-4207

ENERGY PROJECTS UNDER MOU


NAVY ENERGY R&D PROGRAM
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NAVAIR (6.2)
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NAVAIR (6.3)
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NAVFAC (6.3)
NAVFAC (6.4)

4.2.6 Energy Projects under MOU

These projects are conducted by Navy organizations for other federal agencies with funds provided by those agencies. They are generally projects in which the Navy has an interest because, if successful, they can be applied to the naval mission. Table 7 lists the primary MOU projects being done by the Navy.

Table 7. NAVY MEMORANDUMS OF UNDERSTANDING

Navy Performer, Funding Agency	Title and Description	Contact	Telephone Number	Agreement Number	Start Date	Funding
NRL, ERDA	**Resonance Charge Transfer Effects Between Impurity Ions and Natural Atoms in Plasma Boundary Interaction Regions** Demonstrate the importance of ion-atom charge transfer reactions to equilibrium and neutral injection for fusion devices, as well as radiation balance.	R. Elton	(703) 767-2754	E(49-20)-1010	10/76	$60,000
NRL, ERDA	**Advanced Structural Materials Development** Evaluate properties of alloys for advanced nuclear applications including simulation of near-core environment of fast breeder reactor to assess integrity potential of structural alloys used in that e nvironment.	L. Steele	(703) 767-2515	E(49-5)-2110	11/60	$260,000
NRL, ERDA	**X-UV Plasma Spectroscopy in Support of the CTR Program** Use laboratory plasmas to generate X-UV spectra similar to what is expected from Tokamak impurity elements. Use line identification and temperature estimated from the ionized individual species to interpret more complex spectra from multiple impurities in Tokamaks.	D. Nagel	(703) 767-2154	E(49-20)-1008	7/75	$70,000
NRL, ERDA	**Advanced Alloy Development** Develop and evaluate high temperature alloys for cladding and duct applications in breeder reactors. Evaluate swelling resistance using ion bombardment and neutron irradiation in ferritic alloys and determine radiation embrittlement.	F. Smidt	(703) 767-2565	E(49-20)-3029	10/75	$50,000
NRL, ERDA	**Improvement of Lead-Acid Battery for Load-Leveling Applications** Conduct studies to increase utilization of activ e material, extending the service life, and defining system kinetics of lead-acid batteries.	A. Simon	(703) 767-2631	E-77-A-31-1003-01	12/5	$165,000
NRL, ERDA	**Laser Fusion Research** Cooperate in a program of laser fusion research, experimentation, analysis and reporting of results of activities conducted at NRL.	S. Bodner P. Turchi	(703) 767-3152 (703) 767-2725	ES-77-A-01-6021	10/76 4/77	$1,300,000 $200,000
NRL, ERDA	**SOLCHEM** Develop a heat of fusion energy source for cost-effective solar thermal utility power.	T. Chubb	(703) 767-3580	E(49-28)-1024	4/77	$100,000

Table 7. NAVY MEMORANDUMS OF UNDERSTANDING (Cont'd)

Navy Performer, Funding Agency	Title and Description	Contact	Telephone Number	Agreement Number	Start Date	Funding
NRL, ERDA	**Studies Using New Impregnations on Charcoal, Based on the Oxyacid Salts of Iodine** Test a new formulation for impregnating coal base charcoals for trapping radioactive organic iodine compounds developed at NRL.	V. Dietz	(703) 767-2334	EY-76-C-05-5057	9/75	$135,000
NRL, ERDA	**Detection of Trace Concentration of Radioactive Iodine in Nuclear Power Plants and Reprocessing Facilities by Laser Included Electronic Fluorescence** Use an isotopically substituted helium-neon laser in conjunction with lockin detection to monitor fluorescence of $129I_2$. Tests will use a laboratory device and eventually a prototype field instrument.	J. McDonald	(703) 767-2037	EY-76-C-05-5057	11/76	$65,000
NRL, ERDA	**Laser CTR Program** Study physics relevant to laser produced fusion reactions in targets of interest to the fusion community. This research will involve detailed studies on the mechanisms of light absorption, suprathermal electron production, thermal transport, and x-ray and neutron production. Laser fusion may eventually lead to lab sources of thermonuclear burn, and also to power production for military and civilian applications.	S. Bodner	(703) 767-3152	ES-77-A-01-6021	2/72	$1,300,000
NRL, ERDA	**Use of Airborne Germanium Detector for Radiometric Surveying** Determine whether a large volume high energy resolution germanium gamma ray detector should be substituted for the array of 7-9 soldium oxide detectors each 11¼" diameter x 4" thick presently in use.	K. Marlow	(703) 767-5692	E(05-1)-1670	11/76	$15,000
NRL, ERDA	**NRL LINUS Program** Through preliminary feasibility studies of increasing complexity, and with theoretical and engineering support, construct an experimental configuration in which the implosion of rotating, liquid metal cylinders or liners will be used to compress payloads to high energy density.	P. Turchi	(703) 767-2724	E(49-20)-1009	10/76	$550,000

Table 7. NAVY MEMORANDUMS OF UNDERSTANDING (Cont'd)

Navy Performer, Funding Agency	Title and Description	Contact	Telephone Number	Agreement Number	Start Date	Funding
NRL, ERDA	**Theoretical Modeling of Toroidal and Implosive Magnetic Fusion Systems** Develop theoretical and computer computational plasma physics models and apply to Tokamak mirrors and LINUS flux compression systems. Analyze both present day and potential future reactor systems.	N. Winsor	(703) 767-3055	E(49-20)-1006 EX-76-A-34-1000	10/76 10/76	$565,000 $494,000
NRL, ERDA	**Technical Assistance on Reactor Vessels Radiation Damage Analysis** Provide technical assistance to the Nuclear Regulatory Commission for evaluation of radiation damage to reactor pressure vessels and other structural components.	J. Hawthorne	(703) 767-2617	AT(49-24)-0348	8/76	$100,000
NRL, ERDA	**Energy Conversion and Materials Support Technology: Research on Mechanisms of Neutron Radiation Damage to Structural Materials** Analyze and evaluate the effect of radiation damage produced in the environment of a magnetic fusion reactor on the properties of materials.	F. Smidt	(703) 767-2526	RL-75-6507	3/75	$25,000
NRL, ERDA	**Electron Beam Fusion Research** Study intense electron and ion flow in diodes combining experimental, numerical simulation and analytical results.	G. Cooperstein	(703) 767-2290	NP-02-01	7/76	$215,800
NRL, ERDA	**Short Pulsed IR Laser Technology** Conduct infrared laser research development for isotope separation, and ultra-violet laser R&D for isotope separation and nuclear fuel reprocessing applications. Study liquid phase photochemistry applicable to nuclear fuel reprocessing, and investigate novel isotope separation techniques.	W. Watt	(703) 767-2074	E(49-15)-3090	6/75	$350,000
NWC, ERDA	**Coso Drilling Support Program** Cooperate in participation and support of drilling and other activities by Battelle Pacific Northwest Laboratories.	C. Austin	(714) 939-2700	E(49-27)-1006	11/75	$135,000
NWC, ERDA	**Heat Exchanger Technology Assessment** Improve technology of and identify technical deficiencies related to the design, fabrication, testing, and operation of heat exchangers associated with energy conversion systems.	H. Thielbahr	(714) 939-2705	E(49-28)-1008	1/76	$108,000

Table 7. NAVY MEMORANDUMS OF UNDERSTANDING (Cont'd)

Navy Performer, Funding Agency	Title and Description	Contact	Telephone Number	Agreement Number	Start Date	Funding
NWC, ERDA	**Circumsolar Telescope** Distinguish the amount of direct solar radiation from the amount of forward scattered radiation.	R. Kelso	(714) 939-6300	None University of Berkley Letter	10/76	$12,500
NWC, ERDA	**Photovoltaic Power for Remote Sites** Demonstrate feasibility of supplying residential power using photovoltaic power.	J. Kovar	(714) 939-3651	None MERADCOM Agreement	1976	$60,000
NWC, ERDA	**Combined Photovoltaic/Wind Energy Systems** Evaluate feasibility of incorporating a hybrid energy system involving photovoltaic arrays and wind plants into an existing power system.	S. Lee	(714) 939-7218	None MERADCOM Agreement	1976	$30,000
NWC, ERDA	**Heliostats Evaluation** Install and test solar collectors (heliostats) to be used in central tower solar thermal electric generators.	J. Pryor	(714) 939-4325	None McDonnell-Douglas Corp. Letter	1975	$133,000
NWC, EPA	**Pyrotechnic Generation of Inorganic Fumes** Modify aerosol generators used in weather modification for pollution abatement of the environment.	C. Austin	(714) 939-2700	USEP-1A-EPA-IAG-DS0669	4/75	$222,000
NWC, EPA	**Conversion of Trash to Gasoline** Develop a process by which municipal trash could be converted to a high octane gasoline.	C. Austin	(714) 939-2700	EPA-IAG-D7-0781	11/75	$444,000
NAVFAC, ERDA	**Fluidized-Bed Boiler** Develop a fluidized-bed boiler at the Central Heating Plant, Great Lakes, Illinois Naval Base.	J. Berryman	(703) 325-0102	None	10/77	$5,000,000
NAVFAC, ERDA	**Sewells Point Energy Optimization Demonstration Study** Conduct feasibility analysis of various individual and/or combinations of actions that may lead to demonstration of energy optimization community systems and community design in existing communities.	J. Berryman	(703) 325-0102	E(49-28)-1023	5/76	$250,000
NUC, ERDA	**Space Electric Power Office Environmental Test Program**	F. Kawahara	(714) 225-6862	E(49-15)-3058	1975	$50,000
NUC, ERDA	**Study of Feasibility of Optical Detection of Uranium 235 Decay Products in the Atmosphere (Radon Detection)**	E. Wesley	(714) 225-7876	E(05-1)-1672	1976	$85,000

Table 7. NAVY MEMORANDUMS OF UNDERSTANDING (Cont'd)

Navy Performer, Funding Agency	Title and Description	Contact	Telephone Number	Agreement Number	Start Date	Funding
MAT-08T3, ERDA	**MAT-08T3/ERDA Agreement** Define areas of work interaction and give guidelines for conduct of such interaction between MAT-08T3 and ERDA's Division of Conservation Research and Technology.					
NOSC,* ERDA	**Space Electric Power Office (SEPO) Environmental Response and Effects Program** Define possible radiological and ecological implications following accidental marine deposition of radioactive material arising from the Navy's usage of nuclear power devices.	F. Kawahara	(714) 225-6862	E(49-14)-3058	6/70	$155,000
NOSC, ERDA	**Feasibility Study of Optical Detection of Uranium-238 Decay Products in the Atmosphere** Determine the feasibility of optical radar for measurement of atomic cross sections relevant to the remote optical detection of uranium ore.	J. Solomon	(714) 225-7876	E(05-1)-1672	2/76	$124,000

*Naval Ocean Systems Command.

4.3 ENERGY R&D PROJECTS BY SUBJECT

Tables 8, 9, and 10 present the work units or projects within the three strategy areas by subject, rather than by RDT&E categories.

4.4 FUNDING

The authorized funds for conducting the Navy energy R&D program are presented in Table 11. These funds reflect the amounts approved by the recent Program Objectives Memorandum (POM-78). Funding requirements for conducting the Navy R&D program are given in Table 12.

Table 8. ENERGY CONSERVATION PROJECTS

Page	Program Element Number	Project Number	Title and Description	Performer	Contact	Telephone Number
			BUILDING THERMAL ENGINEERING			
B-46	62765N		**Construction Methods and Materials** Determine thermal, structural, safety, and related characteristics of new construction methods and materials.	CEL	E. Vinieratos	(805) 982-5973
B-48	62765N		***Heating and Cooling Loads Computer Simulation*** Develop Loads and Systems Simulation (LASS) model to provide an accurate method of evaluating building heating and cooling loads.	CEL	E. Vinieratos	(805) 982-5973
B-49	62765N		**Measurement of Building Energy Losses** Evaluate and test instrumentation and techniques to locate and measure energy losses from buildings.	CEL	J. King	(805) 982-5973
B-50	62765N		**Concrete Sandwich Construction Materials Tests** Examine characteristics and potential benefits of insulated expansive concrete sandwich construc tion.	CEL	J. Keeton	(805) 982-5793
B-51	62765N		**Low-Energy Structures** Develop and demonstrate low-energy structures concepts for new construction which will satisfy need for reduced energy consumption.	NWC	D. Wirtzl G. Smith	(714) 939-7273
B-91	63724N	Z0829	**Instrumentation Packages for Field Surveys** Determine suitable instrumentation and formulate users guide for conducting field surveys of energy losses.	CEL	J. King	(805) 982-5973
B-114	64710N	Z0371	**Polyurethane Foam Roofing Systems** Determine optimum polyurethane roofing systems and maintenance procedures for new applications on Navy facilities.	CEL	R. Alumbaugh	–
B-120	64710N	Z0371	**Low-Energy Structures** Develop and demonstrate low-energy structure concepts for retrofit construction on existing buildings which will satisfy the need for reduced energy consumption.	NWC	D. Wirtzl G. Smith	(714) 939-7273
			HVAC SYSTEMS			
B-52	62765N		**Seawater Cooling Survey** Perform bathythermographic measurements at four candidate Navy sites.	CEL	J. Ciani	(805) 982-4642

Table 8. ENERGY CONSERVATION PROJECTS (Cont'd)

Page	Program Element Number	Project Number	Title and Description	Performer	Contact	Telephone Number
B-115	64710N	Z0371	**Seawater Cooling for Buildings** Prepare final design, fabrication, instrumentation, and installation of a demonstration seawater cooling system at a selected Navy site.	CEL	J. Ciani	(805) 982-4642
B-119	64710N	Z0371	**Air Conditioning Tune-up Program** Demonstrate a test program to detect, locate and correct problems in Navy air conditioning systems.	CEL	–	–
			POWER GENERATION FACILITIES			
B-53	62765N		**Navy Cogeneration** Determine feasibility of and survey applicable Navy sites for co-generation facilities.	CEL	E. Cooper	(805) 982-5975
B-54	62765N		**Low-Temperature Heat-Recovery Power Systems** Assess the technical and economic feasibility of organic Rankine cycle bottoming systems for improved fuel economy for Navy applications.	CEL	H. Gaberson	(805) 982-5975
B-55	62765N		**Measurement of Energy Losses in Pipelines** Evaluate and test instrumentation and techniques for detecting leaks in various types of pipelines.	CEL	J. King	(805) 982-5973
B-84	63724N	Z0829	**Navy Cogeneration** Perform in-depth analysis for cogeneration plants at Navy sites and develop a planning guide for public works usage.	CEL	E. Cooper	(805) 982-5975
B-90	63724N	Z0829	**Recommendations on Efficiency Improvement** Develop and evaluate new boiler hardware, procedures, and concepts for efficiency improvement.	CEL	T. Fu	(805) 982-5975
B-116	64710N	Z0371	**Navy Cogeneration** Develop and demonstrate a prototype cogeneration plant at a selected Navy site.	CEL	E. Cooper	(805) 982-5975
B-118	64710N	Z0371	**Recommendations on Efficiency Improvement Devices for Conventional Boilers** Demonstrate new boiler hardware, procedures and concepts for efficiency improvement.	CEL	T. Fu	(805) 982-5975

Table 8. ENERGY CONSERVATION PROJECTS (Cont'd)

Page	Program Element Number	Project Number	Title and Description	Performer	Contact	Telephone Number
			ELECTRICAL SYSTEMS			
B-57	62765N		**Electrical Conservation Technology Base** Investigate electrical control, distribution, and power transmission equipment for its conservation potential and applicability for use with alternative energy sources. Develop a lighting application criteria handbook and investigate lighting advances for impact on energy conservation.	CEL	W. Pierpoint	(805) 982-5778
B-58	62765N		**Detection and Measurement of Energy Losses in Electrical Distribution Systems** Evaluate instrumentation and procedures for measuring losses in electrical distribution systems.	CEL	J. King	(805) 982-5973
B-85	63724N	Z0829	**Electrical System Experiments** Verify and apply theory developed from electrical conservation technology base project. Develop and test automatic lighting control systems for quality illumination and electrical conservation. Develop a lighting maintenance scheduling computer program.	CEL	W. Pierpoint	(805) 982-5778
			ENERGY MONITORING AND CONTROL SYSTEMS			
B-59	62765N		**Analysis of Installed Monitoring and Control Systems** Examine existing monitoring and control systems for parameters affecting future procurement and system development.	CEL	D. Johnson	(805) 982-5795
B-87	63724N	Z0829	**Engineering Guidance for Monitoring and Control Systems** Develop and demonstrate a microprocessor time clock and determine capabilities of a modulariz ed approach to monitoring and control system expansion.	CEL	D. Johnson	(805) 982-5795
B-117	64710N	Z0371	**Economic and Operational Potential for High-Technology Modifications of Installed Energy Monitoring and Control Systems**	CEL	R. Stabb	(805) 982-5778
			PLANNING AND OPTIMIZATION			
B-61	62765N		**Energy Conservation Handbook** Prepare an energy conservation handbook for Navy construction applications.	CEL	F. Herrman	(805) 982-5562

Table 8. ENERGY CONSERVATION PROJECTS (Cont'd)

Page	Program Element Number	Project Number	Title and Description	Performer	Contact	Telephone Number
B-62	62765N		**Energy Optimization Handbook for Navy Base Planning** Prepare handbook for predetermining optimum mixtures of environmentally driven power systems and energy conservation systems for planning Naval applications.	CEL	C. Parker	(805) 982-4326
B-63	62765N		**Energy Systems Application Survey** Determine the potential applications of energy conservation devices by conducting a base-by-base market survey.	CEL	C. Parker	(805) 982-4326
B-64	62765N		**Application Engineering Studies** Provide RDT&E assistance to coordinate technology flow between national and Navy energy programs.	CEL	F. Herrmann	(805) 982-5562
B-66	62765N		**Study of Capital Expense Premium to be Allowed for Energy-Saving Physical Plant Investments**	CEL/NWC	C. Parker E. Kappelman	(805) 982-4326 (714) 939-7334
B-89	63724N	Z0829	**Energy Conservation Handbook** Adapt the Air Force/National Bureau of Standards Retrofit Energy Conservation Handbook for Navy applications.	CEL	F. Herrman	(805) 982-5562
			SITE CHARACTERISTICS			
B-67	62765N		**Data Compilation for Energy Consumption and Facility Operational Statistics** Compile on-site statistics and data related to energy demand and consumption at Naval installations. Determine the site characteristics a t Sewells Point Navy Base to characterize energy usage.	CEL	R. Bergman	(805) 982-5377
B-92	63724N	Z0829	***Navy Industrial Use Surveys*** Perform surveys at Navy shipyards and aircraft repair facilities to determine industrial energy losses.	CEL	–	–
B-121	64710N	Z0371	**Industrial Surveys** Determine energy end-use of an aircraft/avionics government-owned contractor-operated facility.	CEL	–	–
B-142	65861N	Z0362	**Energy Usage Statistics for Sewells Point** Determine the site characteristics of Sewells Point Navy Base to characterize energy usage.	CEL	R. Bergman	(805) 982-5377

Table 8. ENERGY CONSERVATION PROJECTS (Cont'd)

Page	Program Element Number	Project Number	Title and Description	Performer	Contact	Telephone Number
			COAL UTILIZATION			
B-143	65861N	Z0362	**Review of Guidance Governing Centralized Steam and Electric Power Generation by Naval Installations**	CEL	D. Williams	(805) 982-4207
			IMPROVED/ADVANCED SHIPBOARD MACHINERY SYSTEMS			
B-73	62765N		**Energy Conservation Aboard Ship** Identify the potential for reduced fuel consumption in future ships through alternative propulsion and auxiliary systems.	DTNSRDC	C. Krolick	(301) 267-2674
B-102	63724N	Z0829	**Advanced Ship Components** Provide model tests and hardware demonstration of machinery systems and components for the present and future fleets.	DTNSRDC	C. Krolick	(301) 267-2674
B-131	64710N	Z0371	**Machinery Optimization** Identify energy-intensive machinery systems in the present fleet and optimize through equipment and procedural modifications.	DTNSRDC	C. Krolick	(301) 267-2674
B-134	64710N	Z0371	**Feedback-Limited Combustion Control System** Develop a feeback controlled system to regulate boiler combustion air.	DTNSRDC	C. Krolick	(301) 267-2674
B-135	64710N	Z0371	**2000 kw Quiet Diesel Generator** Procure, test and evaluate a quiet diesel generator set suitable for installation on ASW combatants.	DTNSRDC	C. Krolick	(301) 267-2674
B-138	64710N	Z0371	**Shipboard Machinery Performance Monitoring**	DTNSRDC	C. Krolick	(301) 267-2674
			IMPROVED HULL MAINTENANCE			
B-98	63724N	Z0829	**Hull Maintenance** Develop improved underwater hull cleaning techniques, biofouling protection system, and hull coatings.	DTNSRDC	C. Krolick	(301) 267-2674
B-127	64710N	Z0371	**Hull Maintenance** Perform at-sea testing of hull cleaning and hull coatings development efforts.	DTNSRDC	C. Krolick	(301) 267-2674

Table 8. ENERGY CONSERVATION PROJECTS (Cont'd)

Page	Program Element Number	Project Number	Title and Description	Performer	Contact	Telephone Number
			PROCEDURAL MODIFICATIONS			
B-136	64710N	Z0371	**Water Resource Management** Formulate procedures and techniques to improve efficiency of fresh-water production and utilization aboard ship.	DTNSRDC	C. Krolick	(301) 267-2674
			BASIC RESEARCH IN ADVANCED POWER SYSTEMS			
B-21	61153N	RR 024-01-01 099-407	**Liquid Metal MHD Power Generation for Nuclear Ship Propulsion** Examine the behavior of turbulence in liquid metal MHD generators in strong magnetic fields.	ONR	J. Satkowski Code 473	(202) 692-4406
B-22	61153N	RR 024-03-02 097-383	**Heat Transfer Problems in Advanced Gas Turbines** Develop the capability to predict the fluid and heat transfer that affect gas turbine performance, e.g., impingement and film cooling.	ONR	J. Satkowski Code 473	(202) 692-4406
B-23	61153N	RR 024-03-02 097-395	**Advanced Topping Cycles** Perform research into thermodynamics and fluid dynamics of convective heat transfer in closed Brayton cycle gases for marine propulsion and power systems.	ONR	J. Satkowski Code 473	(202) 692-4406
B-24	61153N	RR 024-03-02 097-401	**Improved Efficiency Conventional Power Plants: Ceramics for High-Temperature Heat Exchangers** Determine suitability of ceramics for use in high-temperature heat exchangers for shipboard propulsion systems.	ONR	J. Satkowski Code 473	(202) 692-4406
B-25	61153N	RR 024-03-02 099-404	**Liquid Metal MHD Power Generation (Argonne)** Determine the suitability of two-phase MHD generators for use in propulsion systems.	ONR	J. Satkowski Code 473	(202) 692-4406
B-26	61153N	RR 024-03-02 099-412	**MHD Flow Investigation** Analyze two-phase Hartmann flows for Faraday MHD generators.	ONR	J. Satkowski Code 473	(202) 692-4406
B-30	61153N	RR 011-02-42 P05-02.101	**Research on Properties of Materials at Ultralow Temperatures for Use with Turbine Driven Superconducting Generator Motor Systems**	NRL	D. Gubser	(202) 767-2793

Table 8. ENERGY CONSERVATION PROJECTS (Cont'd)

Page	Program Element Number	Project Number	Title and Description	Performer	Contact	Telephone Number
B-31	61153N	RR 021-03-46 R 08-78.101	**Improved Efficiency, Conventional Power Plants: Diesel and Steam Surface Studies for Energy Converters** Study the surface and interface properties of low work function materials used as low-temperature electron collectors for applicability to increasing the efficiency of fossil-fueled plants.	NRL	G. Haas	(202) 767-3577
B-37	61153N	RR 024-01-45 E01-07.101	**Transfer and Storage for Thermal Power Systems for Use with Combined Chemical Dash Power and Nuclear Cruise Power Systems** Perform experimental study of proof-of-concept energy storage unit using heat-of-fusion eutectic salt storage and heat pipe energy transport. Design 2 Mwh storage tank with internal 150 kw steam generator.	NRL	T. Chubb	(202) 767-3580
			BASIC RESEARCH IN *FRICTION REDUCTION*			
B-13	61153N	RR 023-01-82 229-012	**Naval Vehicle Design and Construction: Adhesive and Fatigue Wear Particle Production Rates** Determine the rates of production of adhesive and fatigue generated wear particles in lubricated systems as a function of applied load, speed, and material.	ONR	D. Lauver Code 210	(202) 692-4418
B-15	61153N	RR 023-01-82 229-018	**Mechanism of Heat Generation in Elasto-hydrodynamic Contacts** Determine the magnitude of the temperature rise accompanying the compression of lubricants in bearing and concentrated contacts.	ONR	D. Lauver Code 210	(202) 692-4418
B-16	61153N	RR 024-03-02 097-396	**Material Support Technology: Wear *Reduction in Sliding Systems*** Discover the mechanism by which a complex metal chalcogenide (arsenic thioantimonate) provides a 300-400 percent improvement in wear resistance when compared with molybdenum disulfide.	ONR	J. Satkowski Code 473	(202) 962-4406
B-17	61153N	RR 024-03-07 097-397	**Material Support Technology: High-Pressure Liquid Properties Relevant to Lubricants and Explosives** A theoretical understanding is sought of the time-dependent changes in properties of liquids subjected to high pressure. Of concern are the nonlinear property changes during nonequilibrium conditions.	ONR	J. Satkowski Code 473	(202) 962-4406

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Table 8. ENERGY CONSERVATION PROJECTS (Cont'd)

Page	Program Element Number	Project Number	Title and Description	Performer	Contact	Telephone Number
B-18	61153N	RR 024-03-02 097-398	**Frictional Wear Mechanisms: Machinery Wear Technology** Study the effects of localized heat conductivity, temperature, and pressure on wear mechanisms between solid materials in sliding contact.	ONR	J. Satkowski Code 473	(202) 692-4406
B-19	61153N	RR 024-03-02 097-399	**Self-generated Electromotive Force in Sliding Systems** Determine the interrelationships among metallurgy, chemistry, and environment that control the rate of wear in mechanical equipment.	ONR	J. Satkowski Code 473	(202) 692-4406
B-20	61153N	RR 024-03-02 097-416	**Naval Vehicle Design and Construction: Tribology Planning Study Detailing Technical Approaches Toward the Goal of Energy Conservation** Develop a research plan aimed at accelerating the development of tribology.	ONR	J. Satkowski Code 473	(202) 962-4406
			BASIC RESEARCH IN RELATED CONCEPTS			
B-12	61153N	RR 023-01-82 229-007	**Naval Vehicle Design and Construction: High-Pressure Liquid Viscosity** Evaluate a technique based on autocorrelation technology to measure the time and pressure dependencies of liquid viscosity.	ONR	D. Lauver Code 210	(202) 692-4418
B-14	61153N	RR 023-01-82 229-015	**High-Pressure Viscosity Measurement** Determine the influence of molecular structure on the time-dependent viscosity and density response of liquids and other viscoelastic materials.	ONR	D. Lauver Code 210	(202) 692-4418
B-32	61153N	RR 022-11-41 M01-14.101	**Properties and Engineering Application of Thermostructural Materials** Develop knowledge of such alloys under such high-temperature conditions as exist in conventional power plants.	NRL	P. Shahinian	(202) 767-2117
B-34	61153N	RR 024-01-45 C05-13.101	**Fundamental Study of Electrode Reactions** Study battery electrode processes to develop more powerful and efficient military batteries.	NRL	E. Wells	(202) 767-3617

Table 8. ENERGY CONSERVATION PROJECTS (Cont'd)

Page	Program Element Number	Project Number	Title and Description	Performer	Contact	Telephone Number
B-35	61153N	RR 024-03-41 C05-26.101	**High Temperature and Pressure Chemistry Related to Improved Thermal Energy Conversion** Improve the performance, reliability and efficiency of shipboard boilers, evaporators, etc., through chemical reduction of corrosion, scaling, and sludging.	NRL	D. Venezky	(202) 767-2127
			IMPROVED AIRCRAFT FUEL UTILIZATION			
B-42	62765N	ZF57-571-004	**Aircraft Fuel Conservation Analysis Program** Study and analyze USN/USMC aircraft types and classes, fuel usage and potential fuel savings solutions by design changes and modifications and/or mission operations.	NAVAIR/ NADC	H. Hollenberg W. Miller	(202) 692-7448 (215) 441-2497
B-80	63210N	W05XX	**Long-Endurance Aircraft Engine** Develop a very high efficiency aircraft engine for use in Navy long-endurance patrol aircraft.	NAVAIR	E. Lichtman	(202) 692-2518

Table 9. SYNTHETIC FUEL PROJECTS

Page	Program Element Number	Project Number	Title and Description	Performer	Contact	Telephone Number
			SHIPS PROJECTS			
B-180	62765N	ZF57-571-005	**New Energy Sources/New Fuel Sources** Evaluate synthetic fuels for Navy weapon systems by laboratory analyses of specifications, physical and chemical characterization, and upgrading investigations. Perform assay analyses of synthetic crude for DFM and alternative product yields. Investigate other synthetic fuel sources. Conduct fuel flexibility studies of non-MILSPEC petroleum products.	DTNSRDC	C. Krolick	(301) 267-2674
B-194	63724N	Z0838	**Light Refined Liquid Fuels for S[illegible]s** Perform computer-sponsored [illegible]f synthetic fuel impact in terms of system compatibility [illegible]nd handling problems, fire and safety hazards, and t[illegible]l effects. Consider broader synthetic fuel specifiecations [illegible]reater fuel flexibility.	DTNSRDC	C. Krolick	(301) 267-2674
B-207	64710N	Z0347	**Sea Trials of Synthetic Fuels for Navy Ships** Perform final sea-trial qualifications of synthetic DFM for fleetwide use including identification of handling and personnel training requirements and evaluation of long-term effects on the operational environment.	DTNSRDC	C. Krolick	(301) 267-2674
			AVIATION PROJECTS			
B-170	62765N	ZF57-571-004	**Energy Conversion/Synthetic Fuels** Evaluate physical and chemical characteristics of nonspecification and synthetic JP-5, including reactiv ity, storage stability, and conformity to specifications. Investigate compatibility, performance, safety hazards, and handling requirements.	NAPTC/ NRL	C. Nowack	(609) 882-1416
B-186	63724N	Z0838	**Small-Scale Aircraft Energy Testing with Synthetic Fuels** Determine actual engine performance and emissions characteristics using synthetic JP-5 in tests with T63 and TF-34 engines.	NAPTC	C. Nowack	(609) 882-1416
B-200	64710N	Z0347	**Sea-Going Flight Tests of Synthetic Fuels in Navy Aircraft** Perform final qualification of synthetic JP-5 fuel verifying compliance with maximum performance requirements under conditions of actual carrier-dependent aircraft operations. Develop handling and safety expertise.	NAPTC	C. Nowack	(609) 882-1416

Table 9. SYNTHETIC FUEL PROJECTS (Cont'd)

Page	Program Element Number	Project Number	Title and Description	Performer	Contact	Telephone Number
			GENERAL PROJECTS			
B-166	61153N-24	RR 024-02-41	**Synthetic Fuel Process** Develop processes to produce moderate molecular weight hydrocarbons by low-temperature oxidation of coal with air using catalytic agents, if necessary. Determine the chemical mechanisms involved in the oxidation and decomposition reactions.	NRL	R. Hazlett	(202) 767-3559
			SHORE FACILITIES PROJECTS			
B-176	62765N		**Waste/Fresh Oil Blends** Verify the ability to burn high concentrations and waste oil blended with fresh oil in Navy boilers.	CEL	T. Fu	(805) 982-5975
B-190	63724N	Z0838	**Coal Utilization Systems—Central Coal Gasification Plant** Develop preliminary design and perform feasibility study for fuel gas plant for Navy bases. Determine the expected price of synthetic pipeline quality gas for use in Navy fuel cost projections.	CEL	D. Williams	(805) 982-5976
B-203	64710N	Z0347	**Endurance Testing of Synthetic Fuels in Shoreside Systems** Investigate synthetic fuel performance under extended, full-scale operational conditions. Determine requirements for Navywide implementation and operation.	CEL	T. Fu	(805) 982-5975

Table 10. ENERGY SELF-SUFFICIENCY PROJECTS

Page	Program Element Number	Project Number	Title and Description	Performer	Contact	Telephone Number
			SOLAR PROJECTS			
B-222	62765N		**Solar Projects for the Advanced Energy Utilization Test Bed (AEUTB)** Test solar collector and storage methods integrated with HVAC systems.	CEL	H. Zwibel	(805) 982-5119
B-223	62765N		**Solar Heating and Cooling Design Guide** Provide technical guidance for site selection and evaluation of solar systems.	CEL	H. Zwibel	(805) 982-5119
B-224	62765N		**Preliminary Assessment of Photovoltaic Equipment for Advanced Bases**	CEL	H. Zwibel	(805) 982-5119
B-252	63724N	Z0840	**Applicability of a Photovoltaic System**	CEL	H. Zwibel	(805) 982-5119
B-270	64710N	Z0350	**Demonstration of Photovoltaic System** Determine applicability at an advanced base.	CEL	H. Zwibel	(805) 982-5119
B-225	62765N		**Feasibility of Solar Desalination Applications at Navy Sites**	CEL	H. Zwibel	(805) 982-5119
B-253	63724N	Z0840	**Preliminary Design of a Solar Desalination System**	CEL	H. Zwibel	(805) 982-5119
B-271	64710N	Z0350	**Full-Scale Solar Desalination System**	CEL	H. Zwibel	(805) 982-5119
			APPLICATION AND DATA ANALYSIS STUDIES AND DEMONSTRATIONS			
B-226	62765N		**Advanced HVAC System Testing—Solar Augmented Heat Pump Studies**	CEL	A. McClaine	(805) 982-4207
B-254	63724N	Z0840	**Advanced HVAC System Testing—Solar Augmented Heat Pump Demonstration**	CEL	A. McClaine	(805) 982-4207
B-227	62765N		**Energy Storage Techniques** Define Navy requirements for storage systems integrated with use of local energy sources.	CEL	H. Zwibel	(805) 982-5119
B-255	63724N	Z0840	**Demonstration of Energy Storage Techniques**	CEL	A. McClaine	(805) 982-4207
B-256	63724N	Z0840	**Demonstration of Solar Air-Turbine Generator**	CEL	E. Cooper	(805) 982-4207

Table 10. ENERGY SELF-SUFFICIENCY PROJECTS (Cont'd)

Page	Program Element Number	Project Number	Title and Description	Performer	Contact	Telephone Number
B-228	62765N		**Advanced Power Cycles for Advanced Bases** Evaluate feasibility of alternate fuels for advanced bases.	CEL	E. Cooper	(805) 982-4207
B-229	62765N		**Alternative HVAC Systems Studies** Economic evaluations and comparisons of solar air conditioning systems.	CEL	R. Chapler	(805) 982-5119
B-257	63724N	Z0840	**Alternate HVAC Systems Testing**	CEL	R. Chapler	(805) 982-5119
B-246	62765N		**Site Characteristics** Assemble energy-related environmental-derived data for Navy bases.	CEL	R. Bergman	(805) 982-4116
			WIND PROJECTS			
B-230	62765N		**Evaluation of 5- to 10-kw Capacity Wind Generators to Supply Power for Buildings**	CEL	D. Pal	(805) 982-4207
B-258	63724N	Z0840	**Testing of 5- to 10-kw Capacity Wind Generators to Supply Power to Buildings** Test 5- to 10-kw wind generators in 4-year evaluation project at Navy sites.	CEL	D. Pal	(805) 982-4207
B-232	62765N		**Feasibility of Small-Scale Vertical-Axis Wind Machines** Determine feasibility of small-scale vertical-axis wind machines for conversion of wind energy for space heating.	CEL	D. Pal	(805) 982-4207
B-233	62765N		**Handbook for Application of Wind Power Generators at Naval Facilities**	CEL	D. Pal	(805) 982-4207
B-234	62765N		**Site Selection for Installation and Testing of 100- to 1,500-kw Wind Generators**	CEL	D. Pal	(805) 982-4207
B-260	63724N	Z0840	**Application of ERDA-Developed 100-kw Wind Generators** Collect cost and performance data for a 100-kw unit for 3 years.	CEL	D. Pal	(805) 982-4207
B-272	64710N	Z0350	**Application of ERDA-Developed 1,500-kw Wind Generators**	CEL	D. Pal	(805) 982-4207
			GEOTHERMAL PROJECTS			
B-235	62761N		**Geothermal Utilization Technology for Remote Sites** Identify equipment suitable for use with geothermal power at Naval bases.	NWC	R. Fulmer	(714) 939-7350

Table 10. ENERGY SELF-SUFFICIENCY PROJECTS (Cont'd)

Page	Program Element Number	Project Number	Title and Description	Performer	Contact	Telephone Number
B-236	62761N		**Navy Geothermal Site Assessment** Survey Navy sites to select and prioritize for geothermal development.	NWC	C. Austin	(714) 939-2700
B-237	62761N		**Adak Geothermal Resource Development** Assess potential of Adak site for geothermal development.	NWC	C. Austin	(714) 939-2700
B-261	63724N	Z0840	***Adak Geothermal Resource Development*** Drill exploratory well to verify and characterize resource.	NWC	C. Austin	(714) 939-2700
B-238	62761N		***Coso Geothermal Resource Development*** Evaluate results of USGS and ERDA geological/geophysical studies of Coso sites.	NWC	C. Austin	(714) 939-2700
B-239	62761N		**Geothermal Legal/Institutional Study** Identify legal/institutional problems and provide guidelines to Navy for management of geothermal resources.	NWC	R. Fulmer	(714) 939-7350
B-240	62761N		**Geothermal Impact on Navy Missions** Identify Navy missions and characterize geothermal operations to determine effect on basic Navy missions.	NWC	C. Austin	(714) 939-2700
B-241	62761N		**Geothermal Corrosion Studies** Explore causes and nature of corrosion at specific Navy sites.	NWC	C. Austin	(714) 939-2700
B-262	63724N	Z0840	**Investigation of Geothermal Sites** Conduct detailed evaluation of geothermal potential at Navy sites.	NWC	C. Austin	(714) 939-2700
			WASTE RECOVERY PROJECTS			
B-263	63724N	Z0840	**Demonstration of Packaged Heat-Recovery Incinerator** Study various refuse-derived fuel systems and demonstrate compatibility with Navy shore systems.	CEL	P. Stone	(805) 982-4207
B-242	62764N		**Preliminary Analysis of Combined Liquid and Solid Waste Processes**	CEL	P. Stone	(805) 982-4207
B-264	63724N	Z0840	**Design and Demonstration of Combined Liquid and Solid Waste Processes** *Demonstrate a prototype system for recycling of liquid and solid wastes to energy.*	CEL	P. Stone	(805) 982-4207

Table 10. ENERGY SELF-SUFFICIENCY PROJECTS (Cont'd)

Page	Program Element Number	Project Number	Title and Description	Performer	Contact	Telephone Number
B-244	62765N		**Small-Scale Densified RDF Process Equipment** Determine parameters desirable in a densified RDF for direct thermal conversion.	CEL	M. Boogay	(714) 939-4173
B-265	63724N	Z0840	**Small-Scale Densified RDF Process Equipment Testing** Obtain data on operating RDF system.	CEL	M. Boogay	(714) 939-4173
B-245	62765N		**Conversion of Solid Waste to Gasoline** Develop and demonstrate technology to produce gasoline from trash and to quantify yields and energy efficiencies.	NWC	C. Benham	(714) 939-7263
			COAL UTILIZATION TECHNOLOGY			
B-248	62765N		**Evaluation of New Coal Technologies** Recommend coal technologies for application at Navy installations.	CEL	D. Williams	(805) 982-5974
			OTHER			
B-266	63724N	Z0840	**Development of a Navy Energy Self-Sufficiency Plan/Demonstration** Provide guidelines to Navy installations for selection, identification, and integration of alternative energy sources.	NWC	C. Austin	(805) 939-2700

Table 11. POM-79 FUNDING BY PROJECT, FY 1977-83
(Millions of dollars)

Program Element Number	Project Number	Strategy	FY 1977	FY 1978	FY 1979	FY 1980	FY 1981	FY 1982	FY 1983
62765N		All	4.9	5.4	5.9	6.2	6.8	7.5	8.3
63724N	Z0829	Energy Conservation	0.7	2.1	2.4	3.5	4.9	5.9	
63724N	Z0838	Synthetic Fuels	4.5	3.9	4.3	7.9	13.8	15.9	
63724N	Z0840	Energy Self-Sufficiency	0.6	1.5	2.1	3.8	6.8	8.0	
		Subtotal	5.8	7.5	8.8	15.2	25.5	29.8	29.8
64710N	Z0371	Energy Conservation	2.3	3.0	3.8	5.6	8.0	8.7	
64710N	Z0347	Synthetic Fuels (T&E)	–	–	–	1.1	1.1	1.6	
64710N	Z0350	Energy Self-Sufficiency	1.5	–	–	0.5	1.1	1.6	
		Subtotal	3.8	3.0	3.8	7.2	10.2	11.9	11.9
65861N	Z0362	Energy Management and Analytical Support	0.5	1.1	1.4	1.7	2.0	2.0	2.0
		Total	15.0	17.0	19.9	30.2	44.5	51.2	52.0

Table 12. REQUIRED FUNDS BY CATEGORY AND STRATEGY, FY 1978-83
(Millions of dollars)

Category	Strategy	FY 1978	FY 1979	FY 1980	FY 1981	FY 1982	FY 1983
6.3	Energy Conservation	2.1	6.2	10.7	14.2	16.1	18.5
	Synthetic Fuels	5.5	9.5	12.2	14.9	16.7	18.4
	Energy Self-Sufficiency	1.9	6.6	9.1	8.7	10.0	11.2
	Subtotal	9.5	22.3	32.0	37.8	42.8	48.1
6.4	Energy Conservation	4.5	7.7	13.2	16.9	23.8	29.9
	Synthetic Fuels (T&E)	0.5	2.0	3.0	3.8	7.0	11.0
	Energy Self-Sufficiency	0	2.1	3.9	7.0	9.1	15.1
	Subtotal	5.0	11.8	20.1	27.7	39.9	56.0
6.5	Energy Management and Analytical Support	1.1	1.4	1.7	2.0	2.0	2.0
Total	Energy Conservation	6.6	13.9	23.9	31.1	39.9	48.4
	Synthetic Fuels	6.0	11.5	15.2	18.7	23.7	29.4
	Energy Self-Sufficiency	1.9	8.7	13.0	15.7	19.1	26.3
	Energy Management and Analytical Support	1.1	1.4	1.7	2.0	2.0	2.0
	Total	15.6	35.5	53.8	67.5	84.7	106.1

5.0 PROGRESS AND ACCOMPLISHMENTS

5.1 ENERGY CONSERVATION

Even before the 1973-1974 oil embargo, the Navy had assessed the threat to national security that would ensue if a shortage of foreign oil were to occur, and had already initiated energy conservation measures. The embargo emphasized the importance of such actions. The initial steps to conserve fuel included turning off decorative lighting systems, using the least amount of lighting possible in work areas, lowering thermostats, etc. During FY 1974 and 1975, fleet and aviation training and readiness exercises were reduced, and operational commitments were reduced to a minimum. But these forced reductions in training and operations, while necessary at the time, could have had a detrimental impact on national security and were counter to the Navy's mission. Therefore, steps had to be taken to achieve a greater measure of energy conservation without adversely affecting fleet readiness. Although the initial energy conservation efforts reduced training and readiness exercises, some significant savings were made during those years. Savings of 9.1 percent for ships, 1.2 percent for aircraft, and nearly 12 percent for shore facilities were realized over and above those attributed to reduced operations. These savings resulted from more efficient scheduling and tighter controls in the use of all energy. In FY 1976, the Navy's energy conservation efforts resulted in a significant energy savings. Compared with the FY 1973 base year, energy savings at shore facilities increased from 4.6 million BOE in FY 1975 to 5 million BOE in FY 1976. Shipboard energy savings increased from 4.2 million BOE in FY 1975 to 6.8 million BOE in FY 1976, compared with the FY 1973 base year.

Projects to reduce the energy requirements in buildings and facilities by adding storm windows and doors and additional insulation and by making other retrofit modifications were initiated where funds were available. Ongoing R&D projects were surveyed to determine the potential of those efforts in regard to energy conservation. Projects believed to have the highest potential were emphasized and redefined to develop that potential. For example, an environmental protection project to investigate improved antifouling hull coatings was found to have the potential for a 10 percent annual reduction in fleet fuel requirements and other possible savings because of reduced hull maintenance. Therefore, this R&D project has been redefined to develop its potential in energy conservation efforts. Similar adaptations of the R&D projects of other DOD and federal groups and private industry have been made.

Close liaison is being maintained with all other agencies so that the Navy can benefit from their efforts and share advances gained through Navy-sponsored research with the rest of the nation. Specific progress made by the major SYSCOMs in selected areas is summarized in the following paragraphs.

NAVAIR has devoted most of its efforts toward supporting the Air Force, which has DOD lead responsibility for energy conservation in aviation systems. Beginning in FY 1978, however, NAVAIR, in a new energy conservation effort, will analyze the fuel used in Navy and Marine Corps aircraft by aircraft type and mission. Using these data, possible design changes/modifications, mission operational changes, or both will be studied to reduce fuel usage. NAVAIR is also pursuing the development of a new long-endurance aircraft engine that is expected to contribute significantly to the energy conservation effort, although it is not part of the Navy energy R&D program.

NAVFAC is responsible for energy conservation R&D applicable to the Navy's shore facilities. The Energy Program Office at CEL is the focal point of this effort.

CEL is building an energy technology base, tailored to the Navy's needs, by assimilating advances made in the national energy program. CEL is also evaluating more efficient energy utilization and generation systems and applying the technology, where appropriate, to shore-based facilities.

In thermal engineering, improved design criteria and construction techniques for Navy buildings are being studied for accurately determining the resulting energy savings and cost benefits. The "Construction Methods and Materials" project involved an investigation of the thermal characteristics of walls and ceilings with construction anomalies. The project objective is to determine overall effects on energy consumption of certain selected construction anomalies, and to complete the definition of thermal and O&M properties of available building materials. In "Measurement of Building Energy Losses," methods were developed and hardware procured for "Instrumentation Packages for Field Surveys." The Navy plans to further develop infiltration rate measurement procedures, including infrared photography techniques and heat-flow measurement devices, sulfur hexafluoride and pressurization heat loss measurement techniques, and a correlation analysis for the data derived from the instrument package. "Concrete Sandwich Construction Materials Tests" involved development of a concept for building modular, expanding concrete panels with mid-depth insulation. Twenty panels were constructed and are undergoing thermal and stress tests. The maintenance requirements and cost benefits are also being studied.

In advanced HVAC research, more efficient and reliable HVAC systems capable of being integrated with new power sources are being investigated for use in Navy buildings. Work on seawater cooling indicated that it is a technically and economically feasible method for cooling Navy coastal facilities. A preliminary design for a seawater cooling system was completed for Naval Security Group Activity, Winter Harbor, Maine. The Navywide economic potential for application of seawater cooling systems was also determined. An in-depth study of the characteristics of four potential sites will be conducted, and a demonstration seawater cooling system for Winter Harbor will be developed.

In power generation facilities research, design criteria, modifications, and operations are being analyzed for possible improvement in thermal efficiency and reliability. The

Long Beach Naval Shipyard and the San Diego Fleet Combat Direction Systems Training Center were evaluated as possible sites for total/selective energy systems. A total/selective energy systems handbook was prepared to guide selection and evaluation of such systems for Navy applications. Future studies will include the evaluation of total/selective energy systems potential at other selected Navy sites. In addition, one total/selective energy system will be instrumented to determine performance and operating costs. In the "Low-Temperature Heat-Recovery Power Systems" project, a management plan was developed and system selection criteria identified for a joint Navy/ERDA demonstration of an organic Rankine bottoming cycle system at the Naval Air Station, Bermuda. Plans are to install, monitor and evaluate the system over a period of 4 years. "Measurement of Energy Losses in Pipelines" involved evaluation of sulfur hexafluoride leak detectors and techniques for locating and measuring energy losses in both buried and exposed steam, air, gas, and water pipelines. Plans are to perform comparative evaluations and develop methodologies for Navy use of commercially available pipeline energy-loss detection equipment.

In electrical systems research, NAVFAC is developing the engineering design, operation, and maintenance methods and improvements for systems that consume, distribute, and transmit electrical energy. The "Electrical Conservation Technology Base" project resulted in a draft lighting design criteria handbook containing optimum standard lighting designs based on equivalent sphere illumination and visual comfort probability standards set by the Illuminating Engineering Society. An existing computer program, LUMEN II, used to aid in lighting systems design, was revised to include new routines for artificial lighting, daylighting, electrical lighting controls, and economics analysis of lighting systems. In a project involving electrical systems experiments, task performance versus decreased lighting levels using polarized and radialens diffusers was evaluated. Also developed and evaluated in this project were experimental lighting control systems that automatically maintain specified lighting levels and account for natural daylighting. A solid-state dimming ballast incorporating a microprocessor was developed and will result in optimum lighting system visibility and energy conservation based on photocell control. Also developed was a lighting system maintenance computer program, RELAMP, which computes the benefit/cost ratio for available lighting maintenance strategies. Future plans in the electrical system experiments are to couple the RELAMP computer program to the development of a lighting maintenance scheduling computer program and to develop microprocessor-based lighting control systems.

In EMCS research, the effectiveness of existing EMCS applications is being investigated, and the requisite engineering guidance formulated for the selection and development of advanced systems. An analysis of installed EMCSs involved the evaluation of a system at Camp Pendleton to determine attributable cost savings. Additionally, methods for evaluating the economics, an economics analysis design guide, and evaluation criteria for available EMCS have been developed. NAVFAC plans to report on the recommended utilization and potential economic benefits of conventional EMCSs, develop a microprocessor time clock as the basis for a modular approach to EMCS integration, and update existing conventional EMCSs with state-of-the-art high technology modifications to improve system performance.

In energy conservation systems planning and optimization research, efforts are under way to determine criteria for advanced power system and energy conservation applications, penetration of these systems into the shore establishment, and the methodology for optimizing mixtures of energy conserving systems in planning shore facilities. Development of an "Energy Conservation Handbook" involved providing technical support to the National Bureau of Standards (NBS) in its development of an Air Force conservation handbook, which is to be modified to fit Navy needs in both the retrofit and new construction areas. Work for an energy optimization planning guide involved development of economic payback methodology for determining optimum mixtures of power systems and energy conservation devices at Navy bases. The operational and economic parametric analyses will be automated in the form of a computer program for more efficient sensitivity analysis. "Application Engineering Studies" provide RDT&E assistance throughout the Navy shore establishment to coordinate a continuous flow of technological information from national energy programs to Navy programs; the purpose is to facilitate the application of conservation devices and installation of new power systems. The "Fuel Cost Escalation Study" was completed, and documents national energy and price trends to provide a basis for projecting fuel and energy costs. The prices the Navy can expect to pay for coal, fuel oil, natural gas, and electricity have been projected for 1975 through 2020. A follow-on study to determine the capital expense premium to be allowed for energy-saving physical plant investments continued. Twenty general strategies were determined, and advantages and disadvantages of each were compared.

In site characteristics research, statistics related to energy consumption are being acquired and analyzed. The actual breakdown of energy demand by end-use category was determined for the Pacific Missile Test Center, and methodology was developed to determine end-use categorization at other Navy facilities. Data on energy consumption and demand at Navy installations continue to be analyzed and compiled in relation to characteristics of interest, such as climate, geographical location, fuel transportation costs, and types of energy systems on base. To aid in the on-site energy consumption data collection, a mobile energy data laboratory was procured and outfitted with energy monitoring and measuring equipment. To compare new power systems with current systems, CEL is obtaining data on the operating and maintenance costs and reliability of existing boilers, diesel engines, gas turbines, HVAC systems, and other power facilities.

In coal utilization research, the policy governing central steam and electric power generation by Navy installations is being reviewed in light of current and projected increases in fuel costs. The costs of centralized steam generation are being compared with the costs of using many small existing boilers. CEL is also comparing the cost of purchasing electric power with that of generating it in a central system at a Navy base. Since the Navy plans to convert from oil and natural gas to coal, this study is based on a power-generation system using a conventional pulverized-coal unit with both particulate and sulfur oxide control. The study is being done in three phases. Phase I, which covers existing boiler and steam-turbine generators, has been started, and involves a general study of on-base electric power and steam generation and a site-specific analysis at two Navy shipyards. Phase II will include preparation of preliminary designs and parametric analyses of system performance and cost for both new central and decentralized steam

plants with flue gas desulfurization. Phase III calls for cost-effective studies to determine if electric power should be generated in addition to heat and process steam at new central plants.

The Naval Sea Systems Command (NAVSEA) has primary responsibility for shipboard energy conservation R&D. The R&D program focuses on reducing shipboard energy consumption through improved ship propulsion, more efficient auxiliary systems and operating procedures, improved hull-cleaning techniques, and improved hull coatings. DTNSRDC is the primary Navy laboratory conducting the shipboard energy conservation R&D program.

The "Energy Conservation Aboard Ship" project involved studies of baseline performance efficiency, and life-cycle cost analysis of propulsion, ship's services, electrical, and major auxiliary subsystems for future ships and craft. Fully automated analysis routines for total energy systems and life-cycle cost and effectiveness studies have been developed. Trade-off studies for alternative major auxiliary systems have been conducted, and the future fleet has been characterized. Baseline analysis results are being extrapolated to projected future vehicles.

To establish baseline characteristics that could be used to extrapolate the requirements of future ships and craft, energy-related design parameters and energy consumption characteristics of the major subsystems of destroyer and hydrofoil baselines were determined during FY 1975. During FY 1976, 90 propulsion systems and 48 ship's service electrical system alternatives were screened according to their fuel consumption characteristics over typical mission profiles. Performance, life-cycle cost, effectiveness, and developmental risk assessment of those concepts exhibiting superior fuel consumption characteristics were analyzed in detail. Based on NAVSEA's recommendation, development of a computer program to conduct life-cycle cost analyses over a realistic procurement schedule was initiated; the program will consider logistics cost impact.

In FY 1976, the major energy users (exclusive of propulsion and electrical generation) were identified for the two baseline platforms. A program plan to analyze the energy intensiveness of major auxiliary system options was formulated. A study of destroyer lighting systems was completed in FY 197T; several hardware areas for shipboard suitability studies and cost analyses were recommended. Analyses of destroyer platform hydronic pumping systems were initiated in FY 197T, as were preliminary investigations of HVAC systems.

A STEM program was written that will allow integrated energy studies of all shipboard systems and identification of optimum energy conservative arrangements on a total ship basis. The program was installed on DTNSRDC's CDC 6700 computer, and a series of validating test cases exercised. A library of component data was developed to serve as baseline reference data for the STEM. Energy storage systems potentially compatible with shipboard requirements were studied; the results were integrated into the STEM component library.

As an outgrowth of surveys and assessment studies, several tasks were started in FY 1976 and FY 1977. The response of free-turbine engines for ship's service power applications was analyzed. Energy data for shipboard machinery systems documentation are being compiled, and shipboard diesel noise and failure data are being studied.

During FY 1977, the life-cycle cost computer model was completed and is being used to conduct detailed studies of energy-conservative electrical and propulsion options. Concepts meeting certain criteria for payback period and cumulative life-cycle savings have been recommended for further development. The study to identify shipboard diesel failures and their causes has been completed; the results are being integrated with other ongoing propulsion and electrical studies. Development of advanced propulsion and ship's service systems has been recommended, and procurement action ship impact studies started (as 6.3 or 6.4 tasks as appropriate). A contract was let to study a new type of propulsion-derived ship's service power using liquid cooled generators and associated components.

Shipboard suitability studies of lighting systems were completed, as were the associated cost analyses. Candidate lighting systems are being recommended for further development.

Destroyer hydronic pumping systems were analyzed, as were costs of various energy conservative options. Considerable emphasis has been placed on resolution of technological problems of alternate shipboard components and systems before starting hardware demonstrations in FY 1978 (6.3 or 6.4 tasks).

A request for proposals (RFP) to conduct HVAC systems investigations was prepared and issued. Design criteria will be reviewed, alternative HVAC configurations will be synthesized and analyzed, and cost and effectiveness data will be collected.

The future fleet was characterized in terms of ship type and powering requirements to provide mechanisms for scaling the baseline results to projected future ship types and provide for prioritization of developmental efforts.

Hull maintenance activities were performed in both the advanced (6.3) and engineering development (6.4) programs. Underwater hull cleaning activities involved the continuing evaluation of rotary brush techniques. Methods for in-situ cleaning of sea chests and propellers are also being evaluated. An interim fleet instruction on how to perform underwater hull cleaning has been issued. The Navy started a 2-year test program involving at-sea trials to determine the required frequency and the cost-effectiveness of underwater cleaning techniques.

Some organometallic-polymer-based paint formulations to be evaluated as hull coatings were delivered. Patch-panel static immersion tests on various combinations of the paints and standard Navy primers were started. The Navy Bureau of Medicine (BUMED) completed toxicological tests on many of the delivered paints and approved their use on ship hulls. Keel-to-waterline belly stripes were applied to selected Navy ships. Potential propeller antifoulant coatings and application methods are also being evaluated.

To reduce fuel consumption by the existing fleet, improved machinery alignment and operating procedures were tested at sea on the U.S.S. Holt (FF 1074). Results indicated the fuel consumption rate could be lowered significantly by using the improved procedures, particularly in the cruising range of the ship. The methodology is being extended to other ship classes.

Water resource management efforts are under way to determine techniques to improve the efficiency of freshwater production and utilization aboard ship.

To summarize, the Navy's energy conservation effort has resulted in a reduction in the wasteful use of energy. Additional reductions will be achieved as R&D efforts lead to equipment modifications and developments in ships, aircraft, and shore facilities. Such advances will enable the Navy to achieve its energy R&D goals of reducing Navy dependence on imported petroleum products and of minimizing the impact of increasing energy prices.

5.2 SYNTHETIC FUELS

Through its efforts related to synthetic fuels, the Navy plans primarily to achieve one of its two energy R&D goals–reducing its dependence on foreign petroleum oil. The other goal–minimizing the impact of increasing fuel prices–probably will not be achieved by development and use of synthetic fuels, which are expected to be at least as expensive as petroleum fuels.

The Navy's initial activity in synthetic fuels was begun in FY 1974, when an MOU, originally between the Department of the Interior (DOI) and the Navy, and now between ERDA and the Navy, was developed. According to the MOU, ERDA agreed to provide test quantities of synthetic crudes derived from coal for the Navy to evaluate in small- and large-scale ship power plants. ERDA provided the Navy with 1,238 barrels of synthetic crude from FMC's COED pilot plant for test and evaluation under a project called SEACOAL. Successful completion of preliminary tests on the distilled crude resulted in a sea-trial demonstration in the U.S.S. Johnston. The results of all these tests and evaluations indicated that the characteristics of the COED process synthetic fuel are similar to those of conventional, petroleum-based fuels used in Navy boilers.

The Naval Air Propulsion Test Center (NAPTC) also evaluated this crude as a potential source of JP-5 and found that the fuel cannot meet all of the specifications without additional processing. NAPTC is conducting small-scale tests of this fuel to determine its performance characteristics. Further tests will be discontinued after the small-scale testing, however, because ERDA has decided to close the FMC plant. Future tests of fuels derived from coal will be initiated when the synthetic crudes of other coal processes become available.

Work with synthetic crudes derived from oil shale has included the Paraho oil shale demonstration project; a pilot plant and a semiworks plant are operating. Based on

previous tests conducted by the Bureau of Mines (BOM) and private contractors in the early 1950s, shale oil crude appeared to have better characteristics for middle-distillate fuels than those derived from coal. Therefore, in 1974, the Army, Navy, Air Force, NASA, ERDA, Coast Guard, and MARAD established a joint project to evaluate the shale oil products from the Paraho semiworks plant. In this project, 10,000 barrels of shale oil crude were refined into military fuels (JP-4, JP-5/Jet-A, DF-2/DFM, gasoline, and heavy fuel oil).

The oil-shale-derived fuels were tested in small- and full-scale hardware. The results indicated that, in a majority of the cases, the performance characteristics were within the normal range for the particular hardware. The tests culminated in the successful flight test of a T-39 executive jet by the Air Force, the successful cruise of the steamer Edward B. Green (sponsored by the Navy, MARAD, and the Coast Guard), and the operation of a jeep (L-141 engine) by the Army. During these tests, the fuels exhibited certain operational stability problems that can be solved by improved refinery processing. However, the tests demonstrated the feasibility of using crude shale oil as a feedstock for military fuels.

To demonstrate that a wide spectrum of operational military fuels can be made from shale oil crude, 50,000 to 100,000 barrels of crude will be refined in a typical full-scale commercial refinery to produce a wide range of military specification fuels. The products resulting from this refinery run will then be tested and evaluated in the laboratory, in small-scale hardware, and in full-scale military weapon systems.

"Unifined Kerosene," a fuel derived from Canadian tar sands, was tested in FY 1975. Test results indicated that the performance and operational characteristics of the tar sands JP-5 were the same as those of petroleum-derived JP-5. Fuels derived from domestic tar sands will be evaluated when sufficient quantities of domestic bitumen become available.

In summary, of the liquid synthetic fuels derived from oil shale, coal, and tar sands, shale oil appears to have the greatest potential; its continued evaluation is therefore of primary interest. Initial characterization of domestic fuel from tar sands will be second in priority to shale oil, when sufficient quantities become available. Coal-derived fuels will also be tested when significant quantities become available.

5.3 ENERGY SELF-SUFFICIENCY

To attain energy self-sufficiency, the Navy is developing the capability to use local renewable energy sources at remote and domestic bases, and where possible, to replace liquid hydrocarbon fuels at domestic bases with more abundant fuels, such as coal. The strategy of the Navy's energy self-sufficiency effort, which began in FY 1973, is to test and evaluate various energy systems being developed by other federal agencies or by the Navy in conjunction with other agencies, such as ERDA, EPA, and EPRI. The objective is to develop systems that will reduce the need for liquid hydrocarbons. Systems using

solar, wind, waste conversion, and geothermal energy are being considered. In addition, activities that would increase the utilization of coal as a fuel for shore-based facilities are being planned.

The Navy is active in several solar-related projects. During FY 1977, the solar collector test stand was built at the Advanced Energy Utilization Test Bed (AEUTB). CEL purchased six solar collectors and will evaluate them during the next year. CEL uses the computer program, TRNSYS, to perform solar systems analysis and collector sizing. All of the new data collected by the Navy on solar systems has been presented in the solar design manual distributed during FY 1976. The manual provides guidance for evaluating solar systems for all types of Navy buildings; future revisions will cover cooling advancements and new data on solar systems hardware compiled from continuing CEL hardware tests, ERDA, and other solar programs.

Work on specific applications of solar energy included completion of a study on the potential of solar air conditioning to lower HVAC costs. Results indicated that solar absorption air-conditioning systems will be economically competitive with conventional systems on a life-cycle cost basis in large installations by 1985. A contract has been awarded to evaluate a specific absorption air-conditioning system that looks promising for Navy use.

CEL investigators are also examining technologies that would allow the Navy to use solar energy in the long term to produce electric power, especially for non-CONUS and isolated bases, and possibly for mobile forces. Progress this past year included completion of conceptual designs for a solar-electric turbine generator. Assuming that the generators would be mass-produced, this type of solar-electric system has economic potential.

The Navy has been particularly active in geothermal activities. Most of the effort has been concentrated on exploratory work at the Coso geothermal field at NWC, China Lake, and at Adak, Alaska. At Adak, results from geophysical studies conducted by the U.S. Geological Survey (USGS) during 1976 and 1977 resulted in selection of a promising drilling site. The site is within 5 miles of the Navy facilities on Adak and, if successful, could provide both electrical power and fluids for heating. Also, a report is being prepared at NWC, China Lake, on the recently completed economic utilization study in which the geothermal energy approach for Adak was compared with other approaches, such as the conventional fuels approach used now, wind systems, and a small nuclear power plant. Even at zero growth rate and zero fuel cost escalation, a geothermal system at Adak would pay for itself in less than 8 years, according to the study. Exploratory drilling at Adak, which began during the summer of 1977, has been completed.

The Coso geothermal reservoir at NWC, China Lake, is thought to have an electrical generating potential of up to 4,000 Mw based on ERDA estimates. Exploratory drilling has already begun at Coso with ERDA funding. Because of problems encountered during drilling of the first hole, a new hole will be drilled in late 1977. The Navy is providing support for the exploration activity in the areas of safety, scheduling, environmental management, site preparation, and consideration of specific Navy requirements, for

example, legal/institutional studies. Environmental assessments required for geothermal development at Coso have been initiated in cooperation with the Bureau of Land Management.

To initiate development of the geothermal field at Lualualei on Oahu, Hawaii, the Navy met with industry representatives in March 1977. If the field is developed, the Navy plans to purchase electricity from the producer. Navy involvement in the development of the Lualualei field will be limited to overseeing safety operations and ensuring maintenance of Navy missions and security procedures on the installation.

Wind energy has potential at a number of Navy installations where average wind speeds are high. Thus, the Navy is looking at several types of wind systems to tap this resource. CEL has been conducting field experiments on a 5-kw generator since FY 1976. Power conditioning equipment for the system was redesigned during FY 1977, after a component failure in November 1976. The rebuilt test set-up is operating well, and test results are encouraging. Three commercial vertical-axis wind machines are also installed and ready for testing at NWC, China Lake. Complementing hardware testing in the wind program are site surveys for determining the best Navy sites for application of wind systems. By the spring of 1976, 10 installations or applications had been recommended as having potential for successful demonstration of wind generators. A potential site for one NASA 200-kw wind plant will be selected in FY 1978.

The Navy is continuing to support utilization of waste materials in three areas. First, packaged heat-recovery incinerators are being tested at sites similar to Navy shore facilities with respect to the waste available to feed the system. A Navy-funded 48-hour continuous test of a commercial system at a Xerox plant demonstrated reliability with little operator attention. Preliminary tests to determine processing requirements for RDF systems are being planned for FY 1978. The tests will be conducted with wastes from a Navy installation and will take place at the BOM pilot facility at College Park, Maryland. NAVFAC is also planning for procurement of equipment to build a 15-ton-per-hour RDF plant at Norfolk, Virginia, for converting mixed solid wastes into usable forms for combustion tests in FY 1979.

CEL's work on combined solid and liquid waste processes is integrated with efforts in other solid waste projects, but has been limited to technology surveys to determine the best processes for Navy demonstration and application.

Investigators at NWC, China Lake, have successfully demonstrated in the laboratory a process for converting solid waste to gasoline. Additional bench-scale process development work is in progress, but no significant technical problems are anticipated. The process is particularly justifiable since a 100-ton-per-day plant appears to be economically attractive at gasoline prices above $0.42 per gallon.

To support the national commitment to increase the utilization of coal, the Navy is providing siting and management support for ERDA's fluidized-bed boiler demonstration at Great Lakes, carried out by Combustion Engineering since July 1976. Other Navy

involvements relating to coal technology have been in the area of coal beneficiation technology, primarily the removal of pyritic sulfur. These projects include demonstrations of magnetic separation of pyritic sulfur and thermal separation of organic sulfur.

CEL has published a technical note describing procedures and providing recommendations for lubricant recovery and recycling at Navy shore bases. A related study resulted in award of a contract for evaluation of solvent-recovery equipment for implementation and operational effectiveness. CEL investigators have issued a technical memorandum based on information gathered to date through a literature search and an industry survey on solvent-recovery systems.

6.0 MANAGEMENT RELATIONSHIPS

6.0 NAVY ENERGY R&D MANAGEMENT RELATIONSHIPS

6.1 INTRODUCTION

Because of the universal nature and magnitude of the current energy problem, Navy energy R&D management and planning will be influenced by national and DOD energy-related activities and organizations. National programs and federal legislation will affect opportunities and resources available to the Navy. DOD energy policies and guidelines will directly influence the establishment of Navy energy planning priorities. While the principal concern in terms of the Navy Energy R&D Program Plan is the R&D management relationships of groups involved in energy activities, these relationships must be understood in terms of the broader context. Therefore, this chapter contains general descriptions of the organization, responsibilities, and management relationships of both civilian and military energy activities. Detailed descriptions of the national energy RD&D programs are presented in Appendix C.

6.2 NATIONAL ENERGY ORGANIZATION

On 1 March 1977, the President sent to Congress proposed legislation to reorganize the federal government's energy agencies and programs. He proposed to establish a new cabinet-level DOE by combining the functions of FEA, ERDA, and the Federal Power Commission (FPC), along with the energy-related functions of six other executive and independent regulatory agencies (Figure 7). Among the major responsibilities proposed for the new department are conservation, regulation, research and development, resource development and production, and data management.

While the proposed energy reorganization is being considered, FEA and ERDA will continue to provide leadership and assistance in developing and implementing specific incentives needed to achieve national energy goals. These incentives include encouraging maximum private sector involvement; initiating energy RD&D efforts when the private sector is unable to achieve national goals; and establishing a consistent developmental and regulatory framework that balances the costs and benefits of rapid development of alternative technologies with those of other public needs and requirements, such as human health, safety, environmental protection, and economic stability.

6.2.1 Federal Energy Administration

FEA was established in May 1974 to direct and conduct programs related to production, conservation, use, control, distribution, rationing, and allocation of all forms of energy. The Energy Policy and Conservation Act (EPCA), signed into law on 22 December 1975, establishes FEA's program scope and future direction. The EPCA also

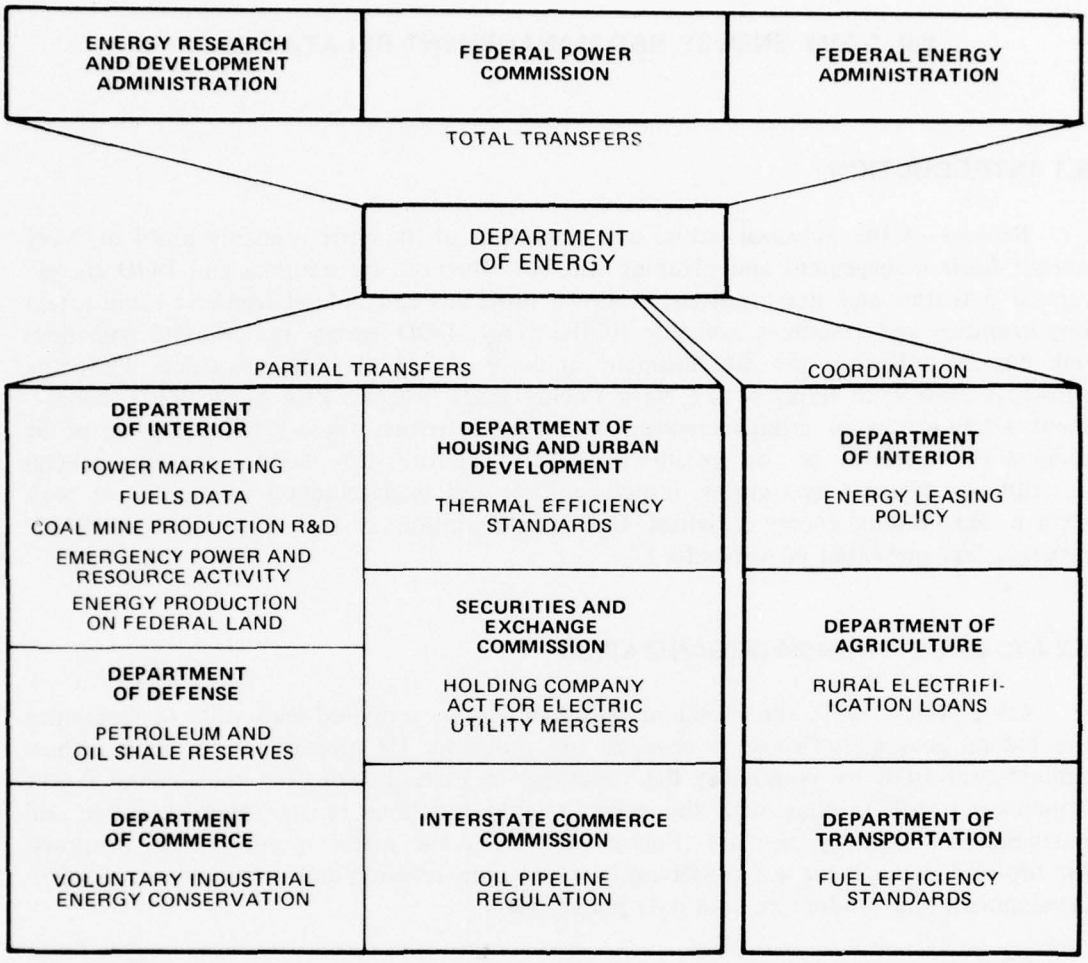

Figure 7. FUNCTIONS AND AUTHORITIES TRANSFERRED TO DEPARTMENT OF ENERGY

establishes national policies on oil price and allocation controls, conservation measures, supply initiatives, and emergency authorities, including contingency planning for protection against another embargo. Specific provisions of the EPCA are:

- Standby authorities enabling the President to implement rationing and mandatory conservation plans to meet U.S. domestic needs and international energy commitments during a future supply interruption.
- Creation of a strategic petroleum reserve to offset the impact of a supply disruption.
- Provision for loan guarantees to develop new underground coal mines.
- Ceiling prices on domestic oil as well as provisions for incentives to stimulate certain types of oil production.
- Conservation of energy through voluntary and mandatory programs applicable to industry, the states, and the federal government.
- Energy efficiency standards for automobiles, and energy efficiency targets for appliances and other consumer products.
- Expansion of a national coal conversion program to reduce the U.S. demand for natural gas and petroleum products.

Through its various offices, FEA sets the general tone and direction of the national energy policy. While its programs complement those of ERDA and DOD, there is little direct interface at this time between the Navy and FEA concerning energy R&D.

6.2.2 Energy Research and Development Administration

ERDA was created by Congress in October 1974 to assume the principal lead for federal energy R&D. Soon after its establishment, ERDA, in compliance with its legislative mandate, began to identify national energy R&D goals. Incorporated into ERDA's first report to Congress (known as ERDA 48) and more recently refined in ERDA 76-1, these goals are to:

- Expand the domestic supply of economically recoverable energy-producing raw materials.
- Increase the use of essentially inexhaustible domestic energy resources.
- Convert fuel resources efficiently into more desirable forms.
- Increase end-use efficiency.
- Protect and enhance the general health, safety, welfare, and environment, as affected by energy.
- Perform basic and supporting research and technical services related to energy.

The significance of ERDA's program, as reflected by these goals, is that it establishes the priorities for all federal energy R&D. It is therefore critical that the Navy be aware of these priorities and that these priorities be reflected in the Navy's energy R&D efforts.

6.3 DOD ENERGY ORGANIZATION

Immediately following the 1973-74 oil embargo, a number of energy-related organizational measures were implemented within DOD. These measures included the establishment of a Defense Energy Policy Council in the Office of the Secretary of Defense (OSD) and a Directorate for Energy, supported by the Defense Energy Action Group, to coordinate actions within DOD and with FEA to meet the energy crisis. The DOD organization for energy management is shown in Figure 8.

6.3.1 Defense Energy Policy Council

The Defense Energy Policy Council, shown in Figure 8, develops broad energy policy guidelines. The Council, chaired by the Assistant Secretary of Defense for Manpower, Reserve Affairs, and Logistics [ASD(MRA&L)], includes representatives of:

- OASD (MRA&L).
- OASD, International Security Affairs (ISA).
- OASD, Planning and Evaluation (P&E).
- OASD, Public Affairs (PA).
- Office, Director, Defense Research and Engineering (ODDR&E).
- Joint Chiefs of Staff (JCS).
- Defense Logistics Agency (DLA).
- Department of the Army.
- Department of the Navy.
- Department of the Air Force.
- Defense Fuel Supply Center (DFSC).

6.3.2 Directorate for Energy

The Directorate for Energy, shown in Figure 8, was established on 2 January 1974 as the DOD focal point for energy matters. The Director for Energy is program manager for energy, and reports to the ASD(MRA&L). As program manager for energy, the Director for Energy:

- Develops a petroleum logistics policy.
- Represents and supports DOD and its positions on energy matters at congressional hearings and interagency forums.
- Assists in the development of DOD energy budgets.
- Serves as the principal point of contact for DOD on all energy matters and implementation of energy policy.
- Manages DOD's energy conservation program.
- Monitors the implementation of the DETG recommendations.
- Monitors and recommends priorities of DOD R&D efforts in energy and energy-related matters.
- Prepares standby allocation programs for DOD.

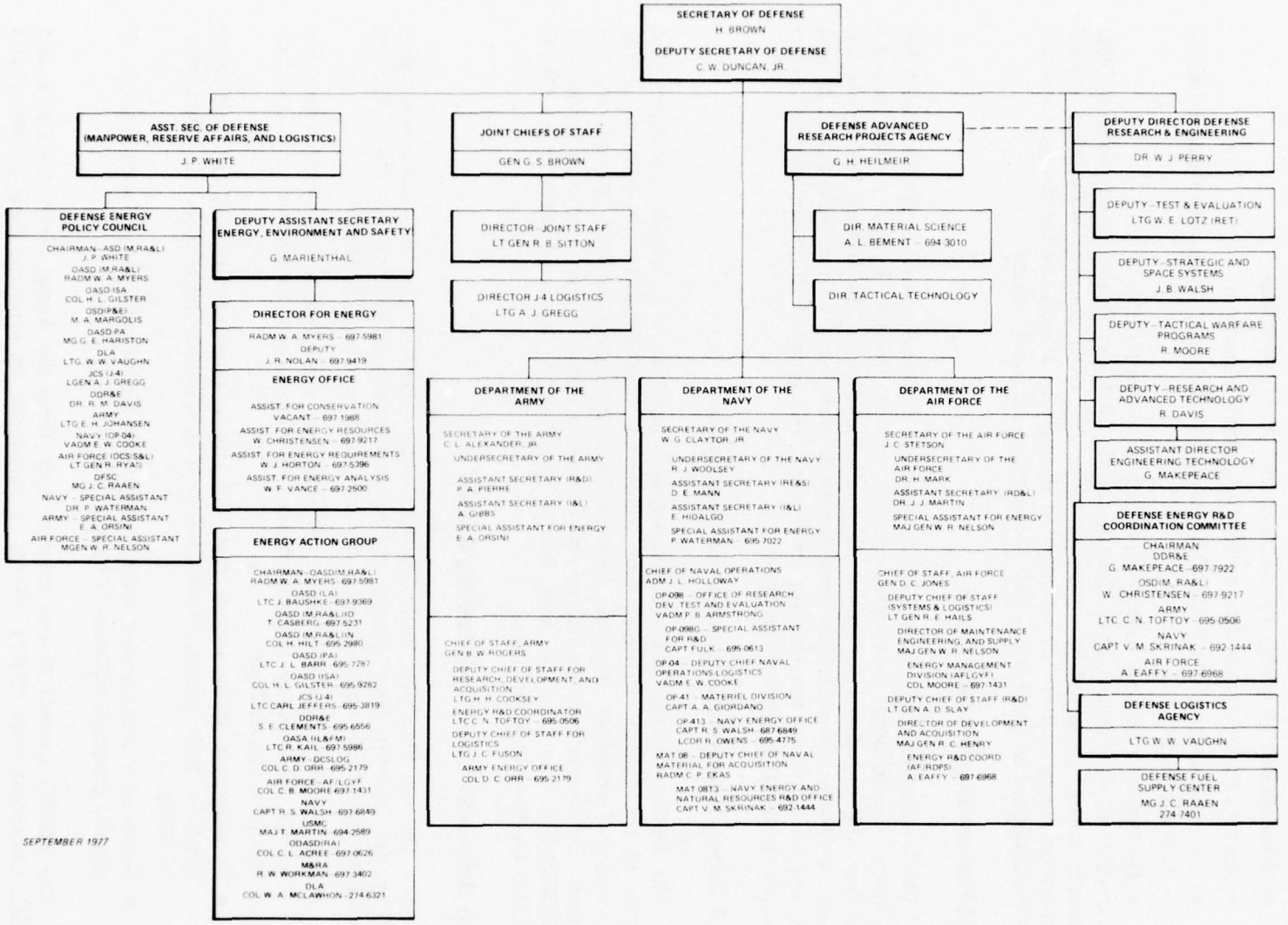

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Figure 8. DEPARTMENT OF DEFENSE ENERGY ORGANIZATION

- Monitors current energy procurement and supply problems.
- Reviews DOD requests for priority fuel supply allocations.
- Serves as secretariat for the Defense Energy Policy Council and Defense Energy Action Group.
- Develops the Defense Energy Information System (DEIS).

In carrying out its responsibilities, the Directorate for Energy works closely with all DOD elements having energy-related responsibilities. All DOD contacts with other federal agencies on energy matters are coordinated through the Directorate for Energy to ensure that presentations of DOD policy and positions are accurately stated.

6.3.3 Defense Energy Action Group

The Defense Energy Action Group, shown in Figure 8, provides the framework for effectively coordinating the implementation of the Defense Energy Action Group's guidelines and provides a forum for information exchange. The Defense Energy Action Group comprises representatives from the DOD staff, each of the Services, DLA, and JCS, and is chaired by the Director for Energy. This group performs an advisory service function for the Director for Energy.

6.3.4 Defense Energy R&D Coordination Committee

The Defense Energy R&D Coordination Committee is a special committee that reports to the Deputy DDR&E. This committee, headed by a representative of the Engineering Technology Division, provides for coordination between DDR&E and the Services. The Committee membership also includes a representative from each Service and ASD(MRA&L). The Director, Navy Energy and Natural Resources R&D Office (MAT-08T3) is the Navy representative.

6.3.5 Defense Synthetic Fuels Steering Group

The Defense Synthetic Fuels Steering Group (DSFSG) is an informal group organized by the Director, Navy Energy and Natural Resources R&D Office (MAT-08T3) to coordinate the synfuel R&D activities of the military services. The DSFSG:

- Assesses, on a continual basis, DOD objectives and programs in relation to other agency and industry programs having an impact upon the production and utilization of synthetic fuels.
- Recommends DOD actions that will ensure timely acquisition and testing of synthetic fuels consistent with the need to minimize R&D costs and duplication of effort.
- Serves as a management team, performing the administrative duties required of specific programs undertaken by DSFSG.

The DSFSG consists of one member each from the Army, Navy, Air Force, and DFSC. Consistent with DOD's efforts to coordinate its synthetic fuels activities with those of other agencies, DSFSG invites other agencies, such as ERDA and NASA, to provide a representative to the group on a project-to-project basis.

DSFSG meetings are held regularly by the Director, Navy Energy and Natural Resources R&D Office (MAT-08T3), who serves as chairman of the group. The DSFSG is presently establishing a long-range DOD R&D plan for the acquisition and testing of synthetic fuels for military use. Member agencies will define test fuel requirements and submit them to the group chairman. The DSFSG reviews responses to RFPs on specific technical efforts, selecting successful proposals for contract awards, and reviews efforts relating to acquisition and processing of synthetic crude. Each project is funded, on a voluntary basis, by DSFSG members interested in that particular project.

6.3.6 Defense Logistics Agency

The Assistant Director, Plans Programs and Systems, for DLA is the focal point on energy matters, with operational and management aspects performed through normal channels by appropriate staff elements. Specific staff elements have been designated to interface with the Directorate for Energy, ASD(MRA&L), in its:

- Implementation of a petroleum logistics policy, as directed.
- Representation and support of DOD and its positions on energy matters at congressional hearings and interagency forums.
- Management of the DLA energy conservation program.
- Recommendations on priorities of DOD R&D efforts in energy and energy-related matters.
- Development of requirements for FEA allocation programs for DOD.
- Recommendations for solutions to current procurement and supply problems.
- Operation of the DEIS and responses to DOD and FEA requests for supply information.

DLA's assistance to and coordination with the Directorate for Energy have been an important facet of DLA's efforts in the integrated management of fuel. The DFSC, the principal subordinate activity of DLA, procures and provides integrated management of fuel supplies.

6.4 DEPARTMENT OF NAVY ENERGY ORGANIZATION

The Navy organization for energy planning is illustrated in Figure 9. The principal energy-related functions are assigned by the Secretary of the Navy, the CNO, and the CNM to the:

- Special Assistant for Energy, OASN(RE&S).
- Deputy Chief of Naval Operations (Logistics), OP-04.
- Director, Navy Energy Office (OP-413).
- Director, Research Development, Test, and Evaluation (OP-098).
- Deputy Chief of Naval Material Acquisition (MAT-08).
- Director, Navy Energy and Natural Resources R&D Office (MAT-08T3).
- Director of Navy Laboratories (MAT-08T1).
- Commanders of Navy SYSCOMs.
- Chief of Naval Research.

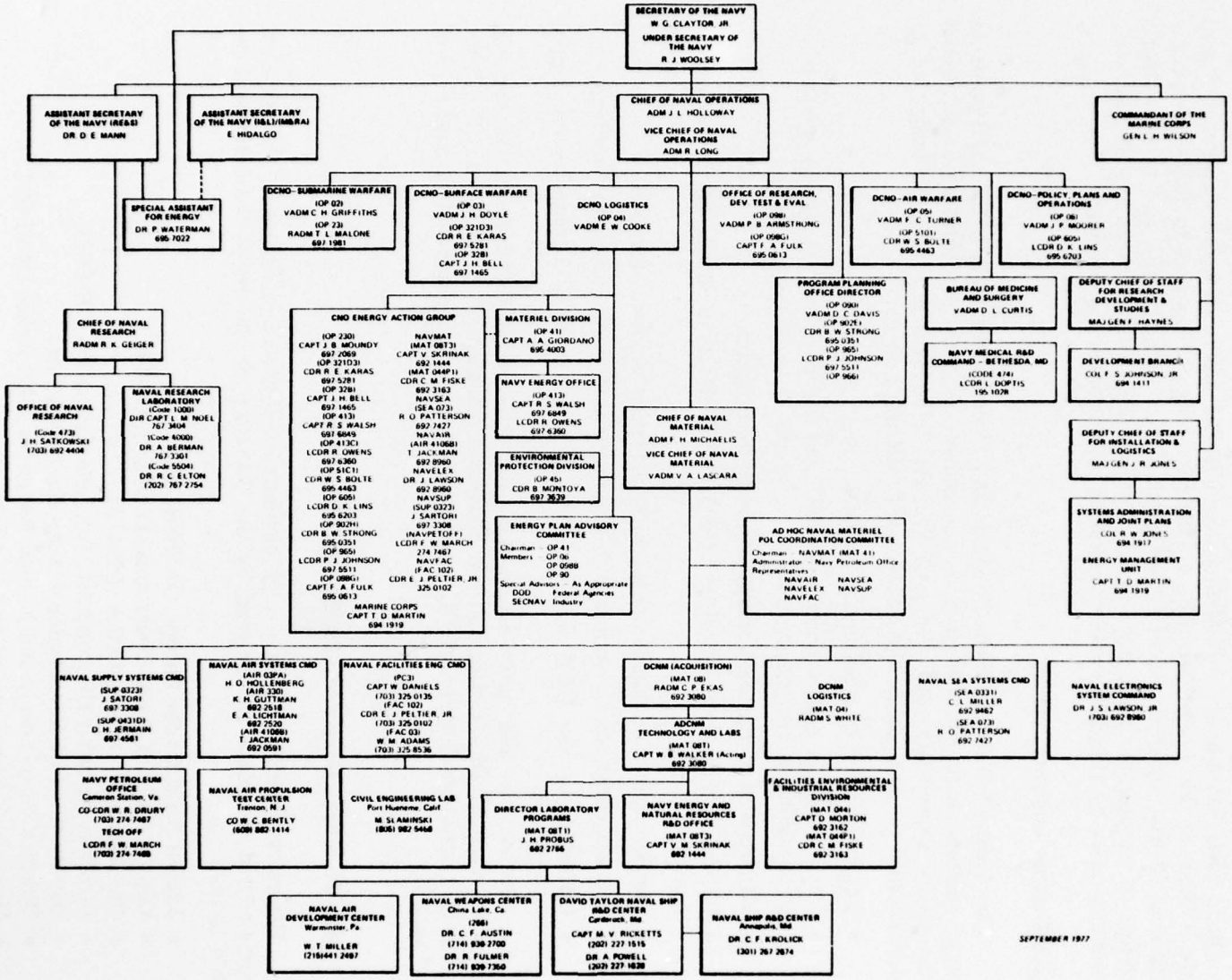

Figure 9. DEPARTMENT OF THE NAVY ENERGY PLANNING ORGANIZATION

6.4.1 Special Assistant for Energy

The Special Assistant for Energy to the Undersecretary of the Navy and ASN (RE&S) reviews and coordinates energy planning activities from a policy standpoint and serves as scientific advisor on energy matters to the Secretary of the Navy, the ASN (RE&S), and the ASN(MRA&L).

6.4.2 Deputy Chief of Naval Operations (Logistics), OP-04

DCNO (Logistics) provides policy coordination and guidance related to energy matters, except for technical and management matters relating to the Naval Petroleum and Oil Shale Reserves. Systems development and implementation relating to conservation, standardization, analysis and determination of requirements, facilities, and operations are coordinated by OP-04. The Director, Material Division (OP-41) provides the principal staff support for energy matters and serves as chairman of the CNO Energy Action Group. The Navy Energy Office (OP-413) is responsible to OP-41 for planning and monitoring efficient use of energy throughout the Navy.

6.4.3 Navy Energy Office (OP-413)

The Navy Energy Office provides policy guidance on all matters pertaining to energy and energy conservation, except those pertaining to nuclear energy; ensures that the Navy can provide the required energy resources to the operating forces and shore establishment; coordinates with the Office of the CNO and acts as a central point of contact for Navy energy and energy conservation matters (other than nuclear energy, basic R&D, and matters under the cognizance of the Office of the Naval Petroleum and Oil Shale Reserves); and participates in functions of interdepartmental interest pertaining to energy matters.

Specifically, the Navy Energy Office:

- Develops, coordinates, and recommends concepts, plans, policies, and systems with respect to the allocation, supply, and the efficient use of energy resources within the Navy in response to requirements of the operating forces and shore establishment.
- Assesses the Navy's energy posture, including the monitoring of requirements and consumption with a view toward optimizing the requirement and consumption patterns in terms of available and projected energy resources.
- Coordinates the efforts of the Naval Material Command (NAVMAT) and various offices of the CNO and develops a long-range energy plan for the Navy. This energy plan is consonant with the federal energy program and DOD directives and ensures that future commercial energy resources will be cost-effective in meeting Navy energy requirements.
- Is the central point of contact for the operating forces on energy and energy conservation matters and recommends guidance to them on these matters, and

initiates, provides incentives for, and monitors energy conservation programs within the Navy that conserve energy without adversely affecting fleet readiness and capabilities.

- Compiles current and future prepositioned war reserve materiel requirements (PWRMR) for petroleum, allocates CONUS PWRMR, monitors PWRMR theater levels, and coordinates worldwide inventory and facility requirements.
- Provides planning advice on the acquisition, construction, repair, modernization, maintenance, and disposal of the Navy's petroleum-oil-lubricants (POL) facilities.
- Develops overall policy for the Navy's energy conservation program, establishes program goals, and evaluates the Navy's energy conservation efforts.
- Is the program sponsor for energy matters within the Office of the CNO, such as the Energy Conservation Investment Program (ECIP), energy program budgets, etc.
- Coordinates with the Headquarters of the Marine Corps on all matters of energy and energy conservation that have or may have an impact on each other's programs.
- Recommends specific energy conservation and management areas for review by the Inspector General of the Navy.
- Acts as program and resource sponsor for Navy energy R&D projects, providing coordination in the application of energy R&D programs with regard to Navy mission and force requirements.
- Is a member of the Defense Energy Action Group and an energy advisor and sponsor of energy-related studies concerning the availability, cost, and type of energy resources in the future.
- Is advisor to the DCNO (Logistics), who is a member of the Defense Energy Policy Council and the chairman of the Navy's Energy Conservation Task Group.
- Provides expertise and backup for Navy witnesses appearing before the OSD, Office of Management and Budget (OMB), and Congress on energy-related matters.
- Advises all cognizant Navy offices on energy implications of international political-military matters.
- Reviews and coordinates the development of the energy aspects of Navy plans and policies and reviews all proposed new Navy programs to determine their impact on energy resources and their projected energy requirements.
- Collaborates on tanker transportation aspects of POL logistics to ensure Navy readiness in peace and war.
- Maintains active and close liaison with the commands, bureaus, and offices of the Navy Department, and with appropriate offices of DOD, the Army, Air Force, and other governmental agencies, as necessary, in the coordination and implementation of its stated functions.

6.4.4 Director, Research Development, Test and Evaluation (OP-098)

The Director, RDT&E (OP-098) carries out the CNO's RDT&E responsibilities and assists the ASN(R&D) with the coordination, integration, and direction of the Navy RDT&E program. The Director, RDT&E supervises and coordinates the POM submission and the RDT&E budget authorization request and FYDP update submission. The Director, RDT&E is the principal supporting witness for the ASN(R&D) before congressional committees. In addition, he makes presentations and provides descriptive summaries and other requested material to Navy staff elements to further explain and support specific R&D programs.

The Development Coordinator for all Navy energy R&D programs, OP-098G, is responsible for accomplishing all RDT&E actions at the OPNAV level associated with the approved program. The main function of the Development Coordinator is to review energy-related R&D documents for accuracy, completeness, and applicability to total Navy R&D requirements. In addition, the Development Coordinator ensures that required R&D documents are submitted on time and that funding profiles reflect energy requirements that are attainable, given the total R&D budget. The Development Coordinator is also the principal advisor to the Director, RDT&E on energy R&D matters for both near- and far-term R&D planning.

6.4.5 Deputy Chief of Naval Material for Acquisition (MAT-08)

The Acquisition Chief, MAT-08, is the senior staff official of NAVMAT, reporting to the CNM on all matters associated with the Navy material acquisition process. His responsibilities encompass all matters associated with conceptual and exploratory development, production, test and evaluation, acceptance, Navy laboratory management, and security assistance programs.

Among the areas for which he is accountable are:

- Development and promulgation of NAVMAT acquisition policy, and implementation of related policy emanating from OMB, OSD, the Secretary of the Navy, and CNO.
- Appraisal of the effectiveness of the acquisition process.
- Reviews of all acquisition programs assuring proper trade-offs between cost elements, and among cost, schedule and performance.
- Promulgation of NAVMAT policy for acquisition management disciplines.
- Optimization of the NAVMAT organization for effective and efficient material acquisition through processing of PM charters, review of SYSCOM acquisition management organizations, and control of all related aspects.

An assistant DCNM (Technology and Laboratories), MAT-08T, assists the Acquisition Chief in his responsibilities and supervises the activities of the Navy Energy and Natural Resources R&D Office, MAT-08T3, and the Laboratory Management Division, MAT-08T1, among others.

6.4.6 Director, Navy Energy and Natural Resources R&D Office (MAT-08T3)

The mission of the Navy Energy and Natural Resources R&D Office is to supervise the planning, execution, and appraisal of NAVMAT's energy and natural resources exploratory, advanced, and engineering development programs. This program supervision, responsive to the CNO and CNM, includes budget planning and review.

The Energy and Natural Resources R&D Office sponsors experiments and demonstrations in the application of the technological advancements resulting from energy R&D efforts sponsored by the Navy, other military departments, other federal agencies, and private industry. Through these efforts, such technological developments can be applied within the Navy as quickly as possible.

To fulfill its responsibilities, the Navy Energy and Natural Resources R&D Office staff must review all Navy programs involving energy technology evolution or applications to assess the feasibility of achieving program goals, the validity of the technical approach, the adequacy of management and funding to accomplish these goals, the feasibility of proposed schedules, and the progress and future prospects of the programs. The Navy Energy and Natural Resources R&D Office:

- Provides the CNM and the DCNM (Acquisition) with balanced appraisals of energy technology programs, makes recommendations to them regarding needed areas of development, and provides the basis for an integrated Navy program.
- Provides technological and reference services for all Navy programs previously described and serves as MAT-08's point of contact for all Navy energy technology programs.
- Assists in answering questions on energy matters directed to the CNM and the DCNM (Acquisition) by higher authorities and assists in like manner in advising higher authorities on such matters, and coordinates these efforts closely with the managers of the projects involved.
- Maintains an informed, up-to-date position on all energy and natural resources R&D and associations with all such R&D groups. In addition, the Director, MAT-08T3 and his assistants are available as scientific and technical advisors on energy technology to the various project managers. The Director, MAT-08T3 provides day-to-day assistance in the Headquarters staff coordination of Navy energy programs and ensures the necessary liaison and coordination of the program sponsor (OP-04), the appropriation sponsor (OP-098), NAVMAT program management organization, and SYSCOMs.

6.4.7 Director of Navy Laboratories (MAT-08T1)

The Director of Navy Laboratories (MAT-08T1) reports to the ASN(RE&S) via the DCNM (Acquisition). He is responsible for matters concerning management of the RDT&E field activities complex within NAVMAT, including:

- Controlling the in-house exploratory development program and the application of programmed funds.
- Ensuring optimum responsiveness of the NAVMAT RDT&E field activities to the sponsoring systems commands, offices, and program managers.
- Guiding the in-house, laboratory Foundation Research and Independent Exploratory Development (FR/IED) programs and controlling the application of programmed funds.
- Controlling the managment and support program and the application of programmed funds.
- Establishing and sponsoring the NAVMAT RDT&E military construction program.

The director has three laboratories reporting to him: NADC, DTNSRDC, and NWC.

- NADC is the principal center for conducting energy programs for the Navy and Marine Corps aircraft applicable to current inventory aircraft systems and to advanced design concepts.
- DTNSRDC is the principal Navy RDT&E center for Navy and Marine Corps vehicles, propulsion systems and auxiliary machinery, logistics RDT&E, and environmental effects.
- NWC is the principal center for conducting geothermal energy development.

6.4.8 Commanders of Navy SYSCOMs

Each SYSCOM commander provides for and meets those material support needs of the Department of the Navy that are within the assigned "material support" responsibility of his command. This general responsibility includes specific responsibility for the research, design, development, logistics planning, testing, technical evaluation, acquisition, procurement, contracting, production, construction, manufacture, inspection, outfitting, supply, maintenance, alteration, conversion, repair, overhaul, modification, and advance base outfitting of naval material for which the command is assigned responsibility. Representative energy-related material support responsibilities, by group, include:

- Naval Air Systems Command
  - Navy and Marine Corps aircraft systems and components (including fuels and lubricants).
- Naval Electronics Systems Command
  - Command/control/communications (platform to platform) systems.
  - Reconnaissance, surveillance, electronic warfare, fire control, and navigation systems.
  - Multiplatform electronic systems not otherwise assigned.
- Naval Facilities Engineering Command
  - Public works, fixed surface and subsurface ocean structures, utilities, and mobile ground equipment not assigned to another command or office.
  - Nuclear, shore power plants.

- Naval Sea Systems Command
  - Ships, submersibles, amphibious craft and vehicles, boats, and manned surface and manned submersible targets, except service craft assigned to NAVFAC.
  - Towing and salvaging equipment.
  - Shipboard components not otherwise assigned, including propulsion and auxiliary power-generation and distribution systems.
- Naval Supply Systems Command
  - Materials handling equipment not otherwise assigned.
  - Naval material not otherwise assigned.

Under the sponsorship of NAVFAC, CEL executes the shore establishment energy RDT&E program. Under the sponsorship of NAVAIR, NAPTC executes the compatibility testing program for engines and new types of fuels.

6.4.9 Chief of Naval Research

ONR encourages, promotes, plans, initiates, and coordinates research related to the maintenance of future Navy power and the preservation of national security; conducts Navy research in augmentation of and in conjunction with the R&D efforts of the respective commands, bureaus, and other agencies and offices of the Department of the Navy and the Marine Corps; and supervises, administers, and controls activities within or on behalf of the Department of the Navy relating to patents, inventions, trademarks, copyrights, royalty payments, and matters connected therewith, as may be prescribed by the Secretary of the Navy. In addition to Headquarters, the Chief of Naval Research commands and provides primary support for NRL, the Naval Biomedical Research Laboratory, and ONR branch offices located in Boston Massachusetts; Chicago, Illinois; Pasadena, California; and London, England.

Under the sponsorship of CNR, NRL is the corporate research laboratory of the Navy and maintains the primary in-house research capabilities and a significant technology development capability in the physical, engineering, and environmental sciences and related technologies–with special emphasis on electronics, materials and general sciences, space sciences and technology, and oceanology. NRL is responsible for R&D in the following energy-related areas:

- Energy sources.
- Environmental effects.
- Materials technology.

6.5 U.S. MARINE CORPS ENERGY ORGANIZATION

The two Marine Corps organizations primarily concerned with RDT&E matters are the Headquarters, Marine Corps (HQMC) and the Marine Corps Development and Education Command (MCDEC) at Quantico, Virginia. In addition, individual personnel assigned to other DOD R&D activities as Marine Corps liaison officers or Marine Corps representatives, and those occupying Marine Corps-sponsored billets in the Tables of Organization of these activities are considered to be part of the Marine Corps' RDT&E organization.

The Marine Corps has responsibility for the development of equipment intended for use of landing forces in amphibious operations. The Deputy Chief of Staff for Research, Development, and Studies (DC/S RD&S) directs the total Marine Corps RDT&E effort to support the acquisition of new systems. He is assisted by the general staff sections in the execution and coordination of the systems acquisition process within their areas of staff responsibility. The Director, Development Center of MCDEC (along with other staff sections) implements the RDT&E efforts to acquire the system or equipment needed to fulfill the established requirement. In addition, the DC/S RD&S directs and coordinates an extensive studies program conducted by civilian contractors, in-house offices, and the other Services, to support the Marine Corps RDT&E effort.

The Commanding General, MCDEC, Quantico, is the field representative of the Commandant of the Marine Corps for DT&E As such, his responsibilities include DT&E related to doctrine, tactics, techniques, and equipment used by the landing forces in amphibious operations, and the coordination of the DT&E activities with the other Service commands having similar responsibilities.

6.6 ENERGY MANAGEMENT INTERACTION WITH OTHER MILITARY SERVICES

Effective interaction in energy matters with the other Services is essential to achieve the goals and objectives of the DOD energy program, utilize the R&D test facilities of the other Services on a cooperative basis, eliminate and avoid redundance or gaps in energy planning and implementation, and accelerate the R&D process.

The Army and the Air Force have established points of contact for energy-related matters. The organization for energy matters of the Army is shown in Figure 10 and that for the Air Force in Figure 11.

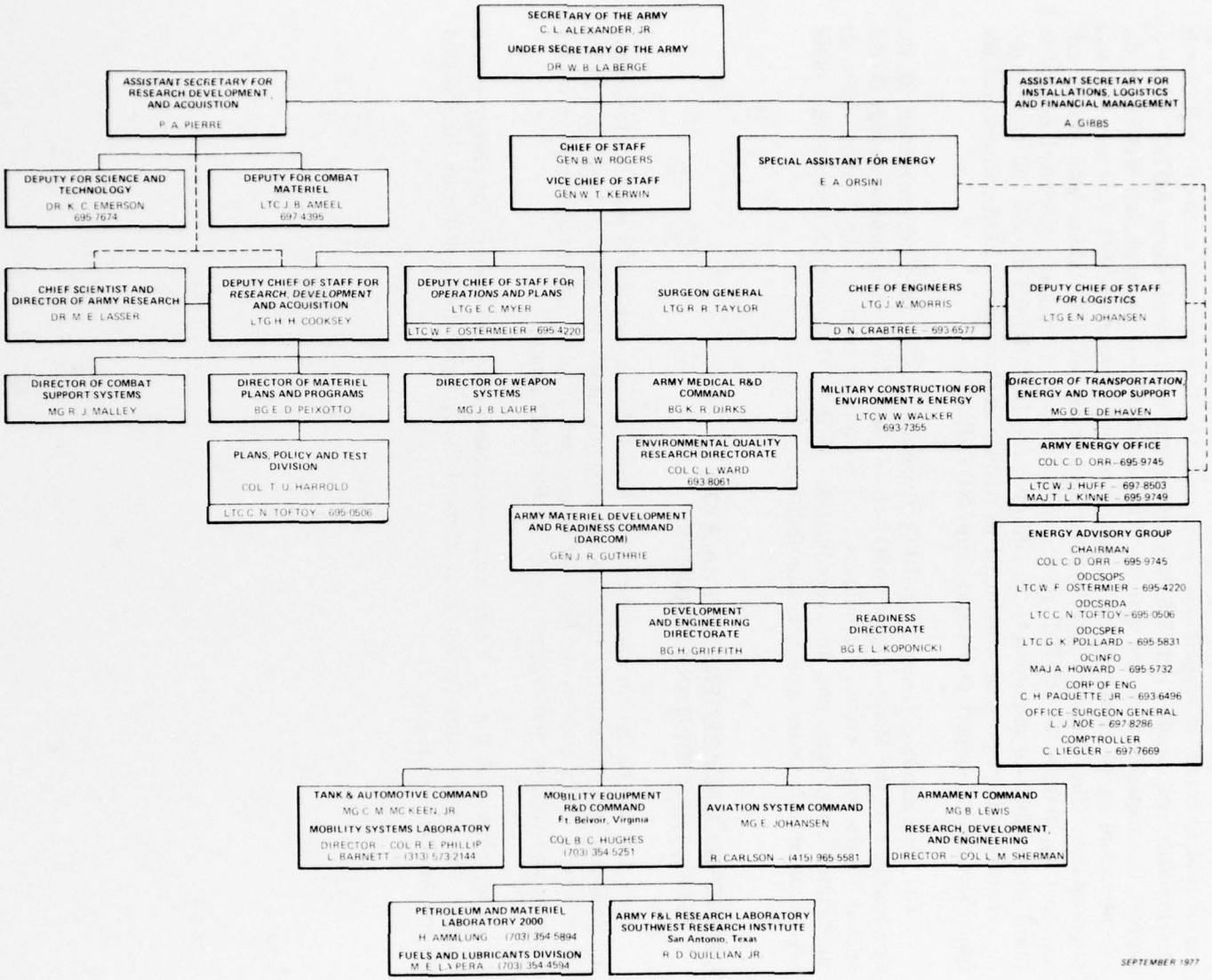

Figure 10. ARMY ENERGY PLANNING AND R&D ORGANIZATION

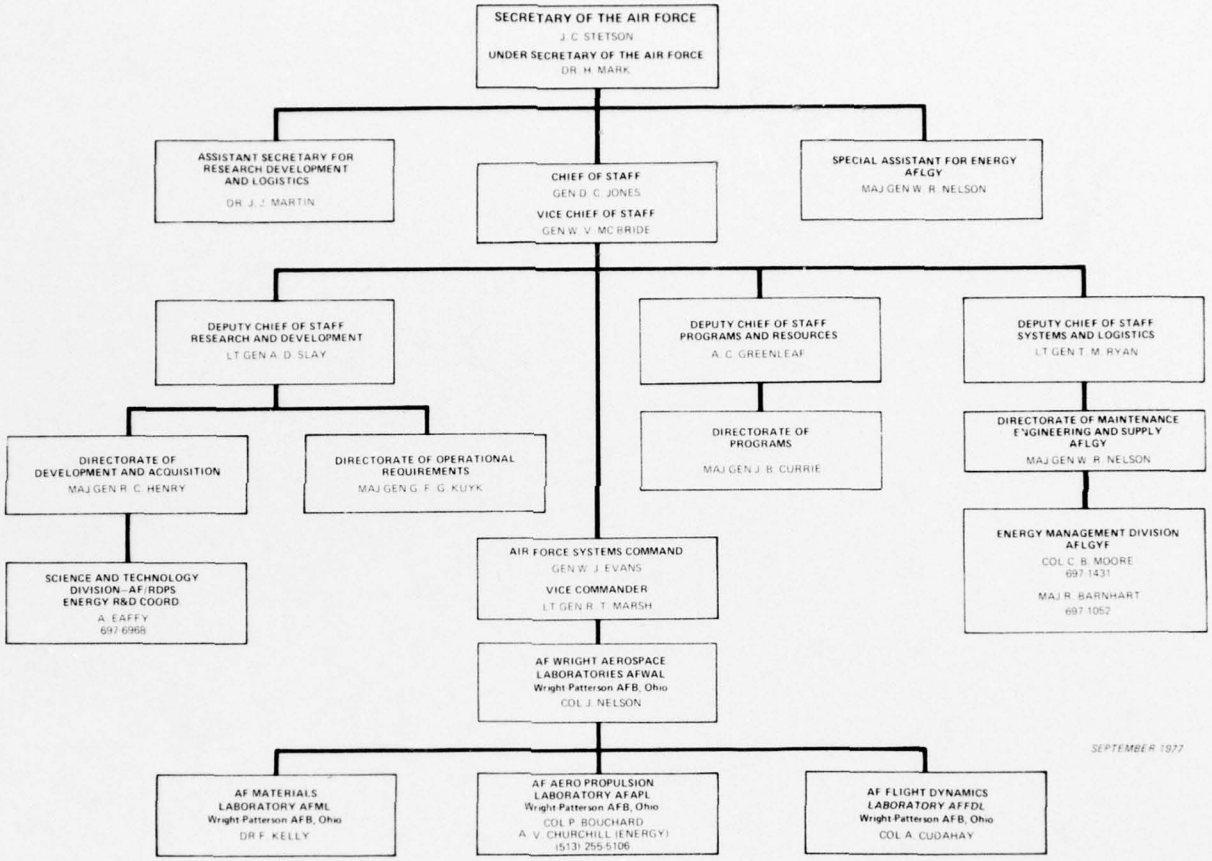

Figure 11. AIR FORCE ENERGY PLANNING AND R&D ORGANIZATION

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Note: A letter (f) following a page number indicates a figure, an (n) indicates a note, and a (t) indicates a table.